DOCUMENT RESUME

ED 340 893 CE 060 048

TITLE	Technician Training for the Semiconductor Microdevices Industry. Final Report.
INSTITUTION	Center for Occupational Research and Development, Inc., Waco, Tex.
SPONS AGENCY	Office of Vocational and Adult Education (ED), Washington, DC.
PUB DATE	Jan 92
CONTRACT	V199A00030
NOTE	309p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC13 Plus Postage.
DESCRIPTORS	Cost Effectiveness; *Curriculum Development; *Electronics Industry; *Electronic Technicians; Industrial Training; Information Dissemination; Manufacturing; Microelectronics; Postsecondary Education; School Business Relationship; *Semiconductor Devices; Technical Institutes; Technological Advancement; Two Year Colleges
IDENTIFIERS	Texas State Technical College Waco

ABSTRACT

The Center for Occupational Research and Development (CORD) carried out four activities to foster semiconductor manufacturing technician (SMT) training: (1) collaboration with industry experts and educators while developing a curriculum to train SMTs; (2) implementation and testing of the curriculum at a technical college; (3) dissemination of information to postsecondary schools, community, and technical colleges; and (4) creation of a model for the development of technician training programs for new and emerging technologies. Four recommendations emerged from the project: (1) cost savings in SMT program implementation can be achieved by using existing labs and using solar cells rather than semiconductors; (2) participants should be given release time from the job while attending classes; (3) participants should have more time to attend classes; and (4) student materials should be developed. (The bulk of the document consists of the following appendices: SMT project time line; technical advisory committee membership list and letter; preliminary task list; curriculum advisory committee and validation list; industry survey/responses statement; Boise State University (BSU) Transformations course description; BSU Transformations demographics and schedule; Texas State Technical College (TSTC) at Waco SMT outlines for nine specialty course; TSTC curriculum and course descriptions; CORD model curricula and course descriptions; press notices; promotion/dissemination of semiconductor manufacturing technology materials; and evaluation report by Glen Bounds.) (NLA)

ED340893

Technician Training for the Semiconductor Microdevices Industry

(V199A00030)

Final Report

to

Office of Vocational and Adult Education
United States Department of Education

January 1992

Center for Occupational Research and Development
601 C Lake Air Drive Waco, Texas 76710
817/772-8972

CE060048

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Technician Training for the Semiconductor Microdevices Industry

Final Report

I. INTRODUCTION AND BACKGROUND

Until the last several years the United States has dominated the semiconductor manufacturing industry, one it invented and developed. Foreign competition, however, has capitalized on the manufacturing techniques for this advanced technology field, and now America finds itself striving to recapture its leading edge in the industry. As with any significant commercialization of a new technology, a key factor is the availability of an appropriately trained technical workforce.

According to the Semiconductor Industries Association (SIA) the total worldwide semiconductor market is expected to top $55 billion by year-end (1991), and will grow to $77.2 billion by 1994.[1] The United States market is projected to rise to 50 percent over 1990 values by 1994 as shown in the chart below:

Projected Growth of U. S. Semiconductor Manufacturing[1]

Year	Shipments	Percent Change
1990	$14.4 billion	(Base Year)
1991	$15.6 billion	+7.8%
1992	$18.0 billion	+15.3%
1993	$20.1 billion	+11.9%
1994	$21.7 billion	+8.1%

The technicians who will support the projected growth must possess a sound foundation of knowledge and interdisciplinary skills that enable them to adapt as a technology changes; yet, while they are multiskilled, they must also possess expertise specific to semiconductor manufacturing. In this industry technicians must be able to operate, maintain, and calibrate modern technical production equipment involved in creating high-vacuums, chemical vapor deposition equipment, photolithography, and ion implantation and be able to take statistical samples and compute factors that describe a system's ability to produce reliably.

Educational institutions are beginning to respond to the need for these highly qualified workers. However, many schools do not have the expertise to conduct a needs analysis and curriculum design for training semiconductor manufacturing technicians (SMT).

In June of 1989, the Center for Occupational Research and Development (CORD) responded to the Department of Education's Request for Application for

1 *Channel Magazine*, November 1991, Vol. 4, No. 8.

Cooperative Demonstrations Programs in High Technology (CFDA No. 84.199A), called Technician Training for the Semiconductor Microdevices Industry. In response to this proposal a partnership composed of CORD, SEmiconductor MAnufacturing TECHnology (SEMATECH), and the Texas State Technical College (TSTC) at Waco agreed to design, develop, and implement an SMT training program for technicians in the semiconductor industry. The curriculum model could then be disseminated to two-year postsecondary schools through the National Coalition of Advanced Technology Centers (NCATC). The request was for $429,477 in federal funds with the project partners providing $107,362 non-federal matching funds or in-kind contributions (a project total value of $536,809).

A grant from the Office of Vocational and Adult Education, U.S. Department of Education, was awarded to CORD as the prime contractor for the period from January 1, 1990, through July 31, 1991. A no-cost extension continuing the grant through October 31, 1991, was given to allow completion of the worker retraining.

II. PROJECT OBJECTIVES AND METHODOLOGY

The contract awarded to CORD was to accomplish the following four goals to foster SMT training:

- to work with industry experts and educators while designing and developing a curriculum to train semiconductor technicians;
- to implement and test the curriculum at a technical college;
- to disseminate information about the curriculum to two-year postsecondary schools and to encourage its implementation at other community and technical colleges;
- to create a model for the development of technician training programs for new and emerging technologies.

To accomplish the above goals, twelve objectives were defined and are delineated below.

1. Organize a Project Advisory Committee (PAC).
2. Prepare a preliminary (technician) task list and a curriculum design.
3. Validate the (technician) task list.
4. Forecast future needs.
5. Design curriculum and courses.
6. Implement retraining classes.
7. Implement an Associate Degree program in Semiconductor (microelectronic) Manufacturing Technology.
8. Provide for semiconductor training program replication.
9. Evaluate the project.
10. Disseminate information.
11. Design a model for technician training development.
12. Report project progress.

Activities associated with each of the above goals and objectives are described in later sections of this report.

III. PROJECT PARTICIPANTS AND ROLES

To accomplish the project goals and objectives, CORD, serving as prime contractor, worked closely with four other organizations. SEMATECH, an industry consortium, provided subject matter expertise; TSTI (now TSTC) provided the demonstration site for implementation of the Associate Degree program; NCATC served as the principal means of disseminating project information to two-year institutions; and Boise State University (BSU) served as pilot site for the retraining of current workers. A project organization chart is shown below, followed by descriptions of each organization and its role.

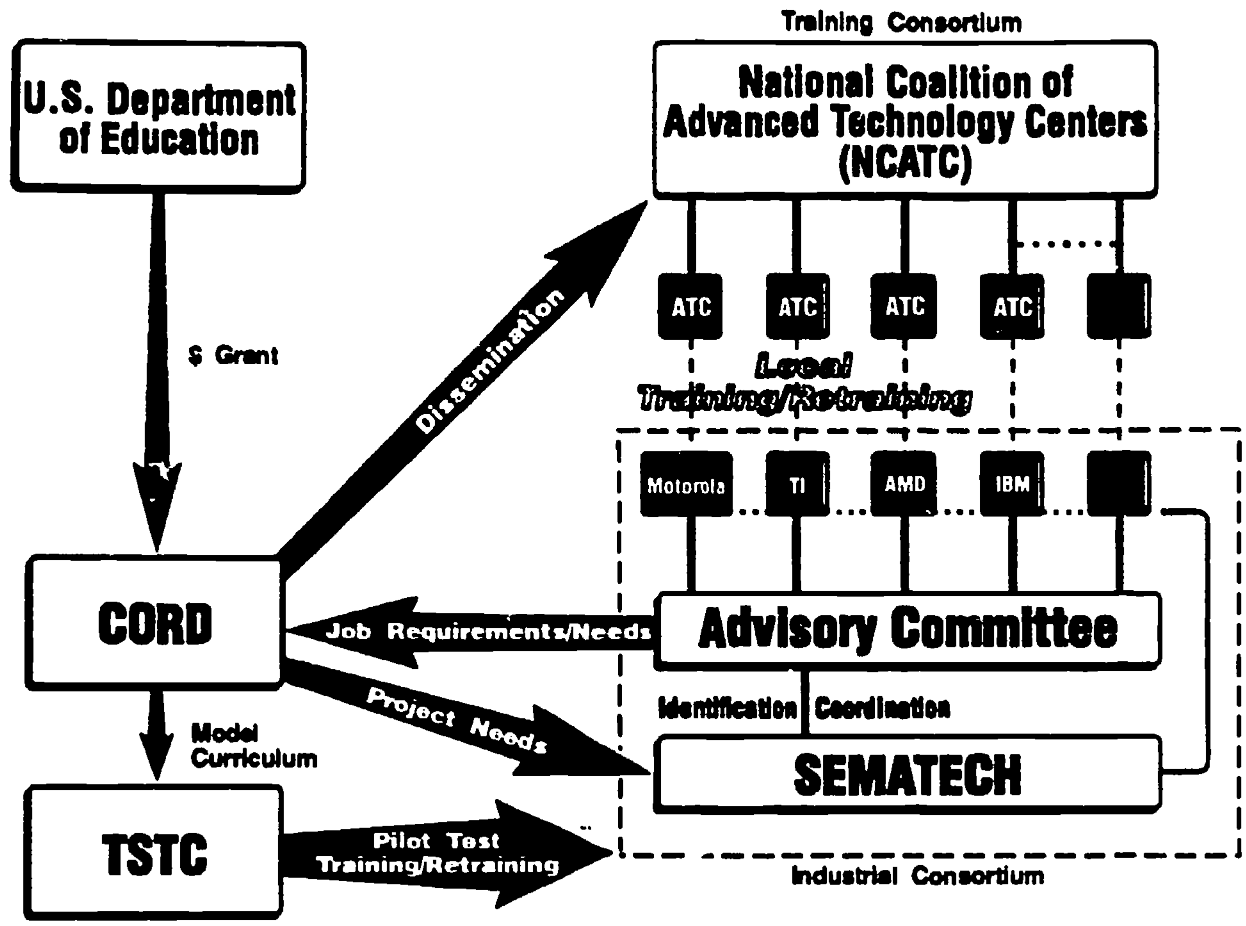

Figure 1
SMT Training Project Model Organization Chart

CORD is a nonprofit organization with a 19-year track record in designing, developing, and disseminating technical curricula in new and emerging technologies. CORD conducts educational research, designs curricula, develops instructional materials and assists various institutions, industries, organizations and state agencies in implementation of complete education/training programs in advanced technological areas.

As prime contractor on the project, CORD coordinated the efforts of the other partners (SEMATECH and TSTC), scheduled meetings, assimilated data, and provided necessary input as to curriculum content and course design. CORD sought and secured agreement from BSU to serve as the pilot-test site for the retraining component of the project. CORD has been active in disseminating information about the project to other two-year schools through the NCATC.

SEMATECH is a manufacturing research and development consortium consisting of 14 major United States semiconductor manufacturers, comprising over 80 percent of the total United States microdevice production. The group pools its wide technology base to develop advanced process equipment and materials to ensure the United States a world-leading manufacturing capability with exclusively domestic content by 1993. SEMATECH integrates new equipment from United States suppliers into a total factory system, such as the state-of-the-art facility in Austin, Texas, evaluating and qualifying the equipment for the equipment manufacturers and the member companies.

SEMATECH supported the project by identifying and assigning experts in specific aspects of semiconductor manufacturing to work on the project. These experts staffed the Advisory Committee, provided input to the task list, and critiqued the curriculum.

TSTC is a statewide technical college system with four campuses located throughout Texas. The Waco campus, which was the pilot site for the two-year technician training, houses an Applied Manufacturing and Engineering Technologies Center. Courses in Robotics, Laser/Electro-Optics and other industry centered advanced technologies are included in the curricula. TSTC is an original member of the NCATC.

NCATC is a coalition of more than 60 technical and community colleges with specific commitment to customized technical education and training. The NCATC promotes infusion of proven advanced technology into United States industries by providing training necessary so that industry will have a readily available workforce, trained in the knowledge and skills needed by local companies.

BSU, College of Technology, School of Applied Technology, Boise, Idaho, prepares certificate, associate, baccalaureate and graduate students for productive careers in technological and engineering related disciplines. BSU's School of Applied Technology was chosen for the worker retraining pilot site, in part due to its proximity to Micron Technology, Inc.—a semiconductor manufacturer that recognized the potential for worker retraining. The BSU College of Technology is an NCATC member.

IV. PILOT SITES

Two curricula were developed as part of this project, one to augment the current workforce and achieve a level of technical literacy, and the other to provide a two-year Associate Degree in Semiconductor Manufacturing Technology. Each curriculum was pilot-tested at a different school.

Associate Degree Demonstration

The TSTC Waco campus offers over 40 instructional programs of which twelve are in applied manufacturing and engineering technologies. With facilities in place to offer training in Nuclear Energy, Laser/Electro-Optics, Robotics and Computer Integrated Manufacturing (CIM), TSTC has many features—such as heavy emphasis in class design on hands-on learning and a willingness to commit to this project—that made it an ideal site to install the pilot two-year curriculum. In addition, TSTC has an excellent working relationship with SEMATECH, and is located only 100 miles from SEMATECH's facility in Austin, Texas.

Retraining Current Worker Demonstration

Several sites, including TSTC at Waco and Austin Community College, Austin, Texas, were considered for the worker retraining portion of the project. When a downturn in the semiconductor industry made it evident that SEMATECH and local SEMATECH members would not be able to support the retraining program, other sites around the United States were pursued to determine their interest and ability to become part of this project.

Representatives of Micron Technology, Inc., Boise, Idaho, who had attended a SEMATECH sponsored workshop in Austin, were very interested in the project. Upon returning to Boise they contacted BSU and encouraged their participation. BSU offers 27 technical education degree programs in a nine building campus complex and several off-campus locations with an enrollment of 1550 in 1991. The offerings range from Construction Management and Health Services to Computer Integrated Manufacturing. To supplement its formal program offerings, the college provides upgrade training for employed adults, apprenticeships, basic academic skills, adult basic education and continuing education.

V. PROJECT ACTIVITIES

The twelve project objectives listed in the proposal (see Section II, Objectives and Methodology) formed the basis for organizing and managing the project. Descriptions of activities supporting each task follow. A project time line is found in Appendix A.

I. Organize a Project Advisory Committee (PAC)

Following the award of the grant, meetings were held with three major manufacturers of microdevices (Motorola, Advanced Micro Devices, and Texas Instruments) and SEMATECH in Austin, Texas. The purpose of the visits was to enlist support from each company's management for employees to serve on the Project Advisory Committee. It was a necessity to have representatives from industry who were knowledgeable about the jobs that technicians do in their companies; this knowledge was required to accurately guide the curriculum design so that graduates would have the necessary knowledge and skills for entry-level work in manufacturing semiconductors.

After the meetings SEMATECH agreed to assign Tom Liberty, a technical executive in SEMATECH Manufacturing Operations, to work on the project full-time for up to four months. Mr. Liberty solicited support from SEMATECH and its member companies in the form of providing members for the Advisory Committee. One representative from each member company was assigned to support Advisory Committee activities. The first meeting was scheduled for April 2-4, 1990, at SEMATECH to explain the project's purpose and goals, to discuss procedures to be used throughout the project, and to elicit the support from all participants. An Advisory Committee membership list is included in Appendix B. The committee met three other times--October 9, 1990, February 4, 1991, and May 9-10, 1991—to assist in refining the list of competencies and the curriculum; as the project proceeded, committee members also offered comments as to the appropriateness of certain equipment being used in the training.

2. Prepare a preliminary Task List and a Curriculum Design

In February 1990, Tom Liberty put together a list of the various technicians employed by major semiconductor companies by title and job description. This list was distributed by SEMATECH in an information release letter to the Technical Advisory Board members. The letter informed potential committee members of this project, requested their participation at a Project Advisory Committee meeting April 2-4, 1990, (Appendix B), and asked for comments related to their companies' use of technicians.

Mr. Liberty and members of the SEMATECH staff developed a preliminary list of tasks that an entry-level SMT student would be expected to perform based upon their expertise and upon input from their coworkers. A copy of the preliminary task list is included in Appendix C.

Independently, curricula and training needs were received from Motorola; Intel; Texas Instruments; Hewlett-Packard; Harris Semiconductor; IBM; Semiconductor Research Corporation (SRC); Micron Technology, Inc.; Portland, Oregon Development Commission; and SEMATECH. Texas A&M University, Bryan/College Station, Texas; Durham Technical Community College, Durham, North Carolina; and St. Michael's College, Winooski, Vermont, also provided information about training related to semiconductor manufacturing. A sample of the material was synthesized into a list of tasks which was shown at the Advisory Committee meeting on April 3-4, 1990.

The committee offered comments as to the procedures for validating all the competencies. CORD developed competencies for all work areas and prepared and distributed them to the Advisory Committee members for validation. Subsequent to the meeting a complete list of competencies was developed, reviewed by SEMATECH personnel, and distributed to Advisory Committee members for validation.

In the same time period, early April 1990, representatives from ten community/two-year technical colleges and two four-year colleges were invited to a meeting at SEMATECH on April 20, 1990. The purpose was to provide technical assistance to CORD and TSTC in assembling the list of competencies and to offer suggestions for the designing and developing of curriculum and implementation of training/retraining programs. A description of the Advisory Committee responsibilities and its membership is found in Appendix D.

3. Validate the Task List

Validation of the task list was accomplished by SEMATECH personnel. Due to a concern for corporate security, CORD was not allowed direct access to the company representatives who could comment on the task list. Rather, SEMATECH handled the technical review and validation of the task list. On May 7, 1990, experts from SEMATECH and industry were sent the preliminary Technician Task List for examination and validation. On June 5, 1990, the final Technician Task Analysis and a proposed curriculum was sent to all Advisory Committee members as well as the educational institution contact persons (a total of more than 50 individuals) for comment.

4. Forecast future needs

At a training workshop sponsored by SEMATECH in Austin, Texas, on October 9-10, 1990, semiconductor industry representatives responded to seven survey questions regarding the evolving industry needs. A copy of the survey and CORD's summary of results is included as Appendix E. In brief, responders said operators will be replaced by technicians who require a broader skill base in math, chemistry, physics and communication. Other areas in which technicians are expected to have expertise are quality, maintenance, engineering, safety and logistics.

The need for a technically trained workforce almost goes without saying for the semiconductor industry. Dr. Gordon Moore, Chairman of IBM, stated on October 16, 1991, at the Microcontamination conference in San Jose, California "We spend $50 million a year on training or about 7-8 percent of the cost to produce wafers." Motorola is studying a possible apprenticeship program to begin at either the high school or community college level. TSTC reports that the SEMATECH member companies who have recently laid off unskilled semiconductor process operators are hiring graduates from their Laser/Electro-Optics, Electronics, Instrumentation curricula because of the skills students gain from these programs.

To broaden its view of the semiconductor industry, CORD developed a working relationship with Semiconductor Research Corporation (SRC). A joint Massachusetts Microelectronics Center (MMC) and SRC study of training needs for technicians for the semiconductor industry, was reported at the SRC Competitiveness Foundation Workshop on Microelectronic Manufacturing Engineering Education, May 30-31, 1991. This survey supports the results of the CORD/SEMATECH survey in defining a technician as changing from routine and prescribed actions toward a proactive role in problem solving. The experienced technician of the future will spend as much as 80 percent of an assignment on problem solving and will need a broad base of math, science, and applied semiconductor technology.

5. Design curriculum/develop courses

Using the validated competencies as an guide to what graduates of a SMT program should know and be able to do, course outlines were formulated. Competencies were grouped according to similar tasks or similar equipment needed to establish basic course design. Course outlines included course descriptions, outlines of classroom activities, lab activities, competencies to be gained, an equipment list, and a list of references. Suggested times for classroom and laboratory activities were assigned to each course.

Once course descriptions had been prepared, the curriculum was constructed incorporating factors such as prerequisites and the need for balanced class loads quarter-to-quarter. A series of meetings among SEMATECH, TSTC, and CORD was used to refine and critique the curriculum and courses. The final result is shown in Figure 2.

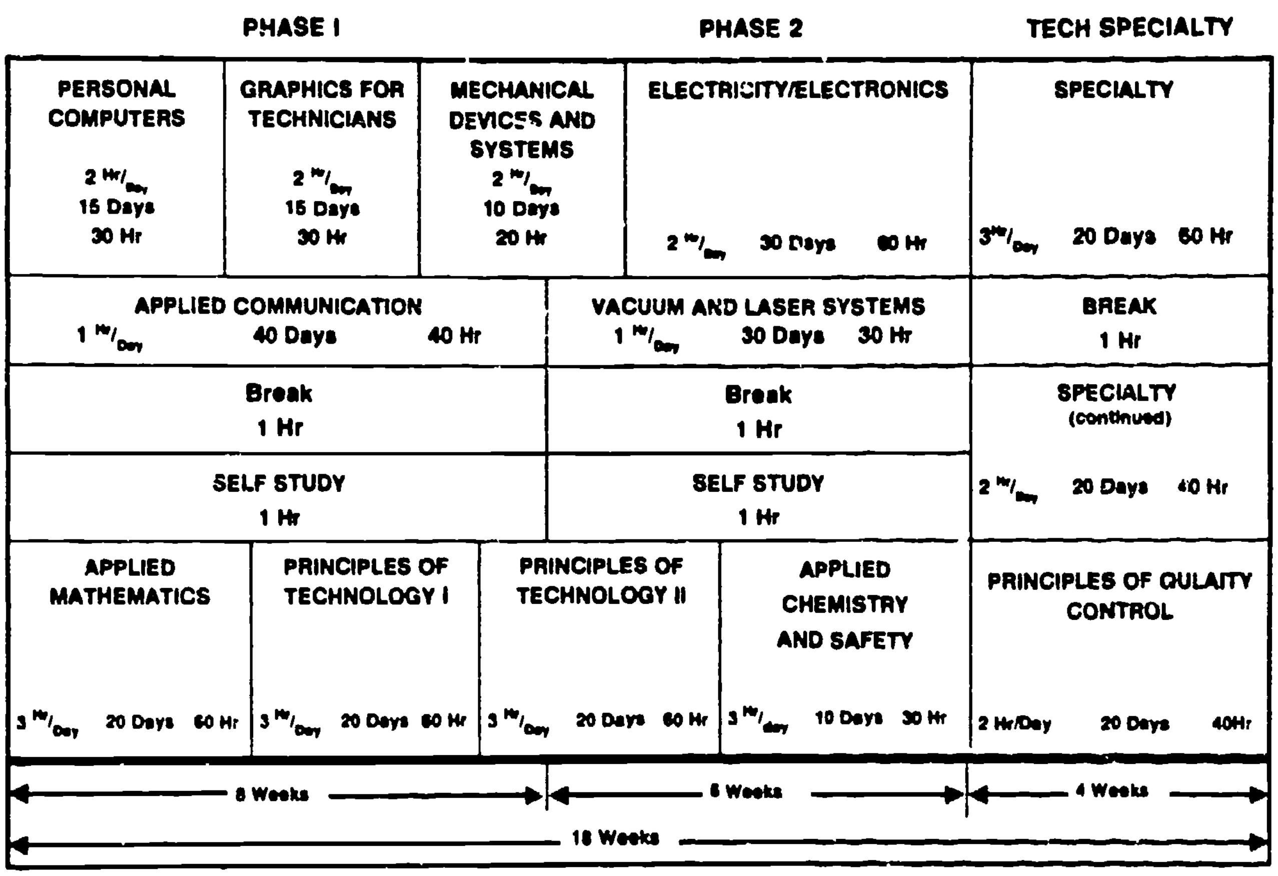

Figure 2

SMT Proposed "Transformations" for SMT Retraining Model Curriculum

6. Implement retraining classes

Retraining for Technology, or *Transformations*, is a curriculum designed to provide technical literacy training to people who desire to work in a technical job. As designed, the retraining curriculum goals are the following:

1) To build a strong math, science, and communication base using applied academic courses (approximately 240 contact hours)
2) To provide training in chemistry, computers, electronics, quality control, and mechanical devices (approximately 180 contact hours)
3) To provide an introduction to the specializations required in semiconductor manufacturing (approximately 120 contact hours).

The pilot site for the retraining portion of the project was at BSU in conjunction with Micron Technology, Inc. CORD worked on-site at BSU beginning in January 1991, to help the BSU staff organize and develop outlines and select materials. As originally designed, *Transformations* is a 14-week, six-hour per day, 420-hour curriculum; however, adaptations made to fit the BSU/Micron needs resulted in redesigning it to 22 weeks at three and one-half hours per day, for a total of 308 hours. Courses taught include *Applied Mathematics, Principles of Technology* (applied physics), *Graphics for Technicians, Mechanical Devices and Systems, Fluid Power, Applied Chemistry, Applied Communication*, and *Computer Fundamentals*. These were taught by contract instructors under BSU supervision. Micron Technology, Inc. chose to provide in-house training in electronics, quality control (normally taught in a *Transformations* setting), and semiconductor processes. The approved curriculum structure and the sequence of courses taught are shown in Figure 3.

<table>
<tr><th colspan="5">BOISE STATE UNIVERSITY/SCHOOL OF TECHNOLOGY</th><th>MICRON TECHNOLOGIES IN HOUSE OR LATER BSU TRAINING</th></tr>
<tr><td>PERSONAL COMPUTERS
2 Hr/Day
15 Days
30 Hr</td><td>GRAPHICS FOR TECHNICIANS
3-1/2 Hr/Day
9 Days
31-1/2 Hr</td><td>MECHANICAL DEVICES AND SYSTEMS
3-1/2 Hr/Day
6 Days
21 Hr</td><td>APPLIED COMMUNICATION/ COMPOSITION
1-1/2 Hr/Day
13 Days
19 1/2 Hr</td><td>FLUID POWER
3-1/2 Hr/Day
8 Days
28 Hr</td><td>ELECTRICITY/ ELECTRONICS</td></tr>
<tr><td>APPLIED MATHEMATICS
UNITS: A, B, C, 1-10, 13
3-1/2 Hr/Day 12 Days 42 Hr</td><td>PRINCIPLES OF TECHNOLOGY I
UNITS: 1-5
3-1/2 Hr/Day 14 Days 49 Hr</td><td colspan="2">PRINCIPLES OF TECHNOLOGY II
UNITS: 6, 7, 9-11
3-1/2 Hr/Day 14 Days 49 Hr</td><td>APPLIED CHEMISTRY AND SAFETY
3-1/2 Hr/Day
9 Days
31-1/2 Hr</td><td>PRINCIPLES OF QUALITY CONTROL</td></tr>
<tr><td colspan="5">← 22 Weeks →</td><td></td></tr>
</table>

Figure 3

SMT Approved BSU/Micron Retraining Model Curriculum

The Micron trainees normally worked shifts of twelve hours per shift, three days per week. Micron allowed employees one and one-half hours time off per day to attend classes; employees spent two hours of personal time to make up the needed time. Nineteen of the twenty trainees completed the course; one dropped due to illness. Micron provided the training in electronics and quality control. Nearly all Micron workers completed the retraining program; sixteen have elected to continue technical training by participating in in-house programs offered by Micron or by enrolling in an accredited program at BSU or another school. As a result of their experience with the pilot program, Micron is planning to send more workers through the additional sessions of retraining, and is discussing possible implementation of the TSTC Associate Degree program with BSU.

To make up some of the difference, Micron taught the electricity/electronics, quality control, and semiconductor process training in-plant with materials they were already using. CORD supplied training materials for *Applied Mathematics* (units A,B,C, 1-10, and 13), *Principles of Technology* (units 1-7 and 9-11), *Graphics for Technicians* and *Mechanical Devices and Systems.*

A portion of the BSU course in fluid power using Vickers fluid power trainers and workbooks was structured. BSU also prepared the Personal Computers, Communications/English Composition, and Applied Chemistry modules. Block diagrams of the proposed and implemented curricula are shown in Figures 1 and 2. Greater detail on these modules is found in Appendix F.

Micron selected 20 workers from among its employees for the program and the following student parameters were tracked:

- Attendance
- Pre- and post test scores in writing, reading, algebra, numerics, general math, *Principles of Technology* (applied physics) and fluid power
- Post test scores in graphics and mechanical devices.

Since the students worked three days a week, and classes were conducted four days a week, some students had difficulty attending all the classes, attributing to attendances ranging from nearly perfect to about 60 percent. The fact that some workers were required to work overtime probably had a negative effect on attendance and scoring. Post-test gains over pre-test scores were noted in numerics, algebra, *Principles of Technology* and math. (Test scores are compared in Appendix G). In spite of the heavy time demands for the students to perform their jobs, attend classroom training, and complete homework assignments, student comments were generally favorable. Micron plans to continue training the workers and send more of its workers through the same training. Instructors' evaluations indicated that this was a dedicated group of students with varying levels of ability. The *Applied Mathematics* and *Principles of Technology* instructors considered the courses to be too short. It should be noted that because of time restrictions *Applied Mathematics* was taught in 42 contact hours where normally CORD recommends 60 hours, and *Principles of Technology* was reduced to 84 hours where 120 hours is recommended. No course was considered too long.

7. Implement an Associate Degree program in Microelectronics Technology

TSTC faculty used the model Associate Degree curriculum as a guide; differences were caused primarily by state requirements for specific courses and by the substitution of existing courses for recommended courses. On May 15, 1990, TSTC in Waco, submitted the proposed Associate Degree curriculum to the Texas Higher Education Coordinating Board; approval was granted by the Board on August 15, 1990, which opened the way for TSTC to offer a pilot-test curriculum that fall.

A major challenge has been installation of a working semiconductor fabrication laboratory in a cleanroom environment. Because modern integrated circuits require ultraclean environments which are very expensive to produce and maintain, such facilities were ruled not feasible for the pilot program. The TSTC instructor recommended the manufacturing of silicon solar cells (photovoltaics) as a student project. Working solar cells can be fabricated with line spacings of about a millimeter (1 mm or 0.001 meter = 1000 microns), some 100 to 1000 times larger than a computer chip, thus much more practical for instructional purposes. Solar cells use the same patterning, layering, doping and metallizing processes as are used in making computer chips but can be fabricated in a less-clean cleanroom, in the class 100,000 to 50,000 range. Such a room still requires more efficient filtering than a typical office, but is much more manageable in a teaching environment and less restrictive and expensive.

TSTC received approval to purchase complete and functional solar cell processing equipment for $64,000. The solar cell manufacturer also donated a diffusion furnace. Additional equipment was received as contributions in-kind from Texas Instruments, SEMATECH, and other manufacturers. In all, more than 40 pieces of equipment and other accessories have been received, most as contributions. The contributions have a new value of nearly $8 million.

TSTC placed selected pieces of this equipment in a modified chemistry laboratory of about 1,000 square feet, using existing acid-handling drains, sinks and safety showers. Such a facility is sufficient to do the basic chemical processes in support of solar cells and other less sensitive projects. To house all the equipment will require more than double this area, and plans are being made for future expansion. Laboratory space is shared with other departments for vacuum systems, computer, and electronics training.

From the model curriculum, TSTC developed nine specialty core courses for semiconductor manufacturing covering all process areas identified in the task analysis, and modified technical core courses (e.g., Vacuums 1 and Lasers) to meet the needs of the program. Outlines of the courses are included in Appendix H. Basic core courses such as English and economics remain as standard courses without change.

TSTC developed an attractive two-color, one-sheet brochure (printed on two sides) and a promotional video for the SMT program which has appeared on local television. Even so, students select courses in lasers, instrumentation and control, electronics, and computers over SMT. Prospective students inherently understand the need for lasers and computer maintenance but do not know what an integrated circuit or chip is. Semiconductor manufacturing being such a new technology and this being a new program, it is expected that enrollment will increase with time.

Ten students enrolled in the first year as full-time SMT majors and six completed the third quarter. Another dropped during the summer fourth quarter. The fall quarter brought the enrollment up to nine SMT majors. Seventeen students majoring in other areas such as Laser/Electro-Optics and Electronics have selected courses in semiconductor technology as technical electives.

8. Provide for Semiconductor Training Program replication

The detailed curriculum material found in Appendix I of this report will allow replication of the SMT program at other schools. It is unlikely that any school will take a snapshot of the TSTC curriculum and produce an identical program. Needs of local industry and the ability to obtain and provide cleanroom laboratory space for that equipment will determine the local structure. Local and state educational board requirements may impact basic and technical core content requiring adjustments in schedule and technical specialty course content.

CORD will produce a Curriculum Guide for implementation that will contain all the material in this report plus additional information on curriculum models, bridge programs and data of interest to the educator. This handbook is scheduled to be available in early spring of 1992.

9. Evaluate the project

The project evaluation is covered in Section VII below.

10. Disseminate Information

The dissemination is covered in Section VI below.

11. Design a model for technical training development

The SMT curriculum was designed based upon experience gained by CORD in several other advanced-technology fields. This experience has shown that there is a group of courses (a core) that is necessary in several disciplines. The courses provide the fundamentals of science and mathematics, humanities, economics, and courses that deal with the function of discrete system component parts. It is the core that provides the broad-based interdisciplinary skills necessary for technicians in today's work environment.

To provide the specialty training necessary in a specific field, such as semiconductor manufacturing, courses are designed to address the attributes of that field. Nine courses were designed for the SMT project; their outlines are included is Appendix J of this report. The advanced technology model curriculum structure, showing course titles is shown in Figure 4a; the SMT model curriculum, indicating the specialty course titles is shown in Figure 4b.

For retraining of current workers, the curriculum was based upon successful projects CORD has conducted at other locations. The structure was shown in Figure 2, in Section V, part 7. It is based upon the need for certain workers in a plant to have an increased knowledge of modern technologies and how they affect today's workplace. It is not the intent of this curriculum to educate technicians, rather to provide a technology foundation.

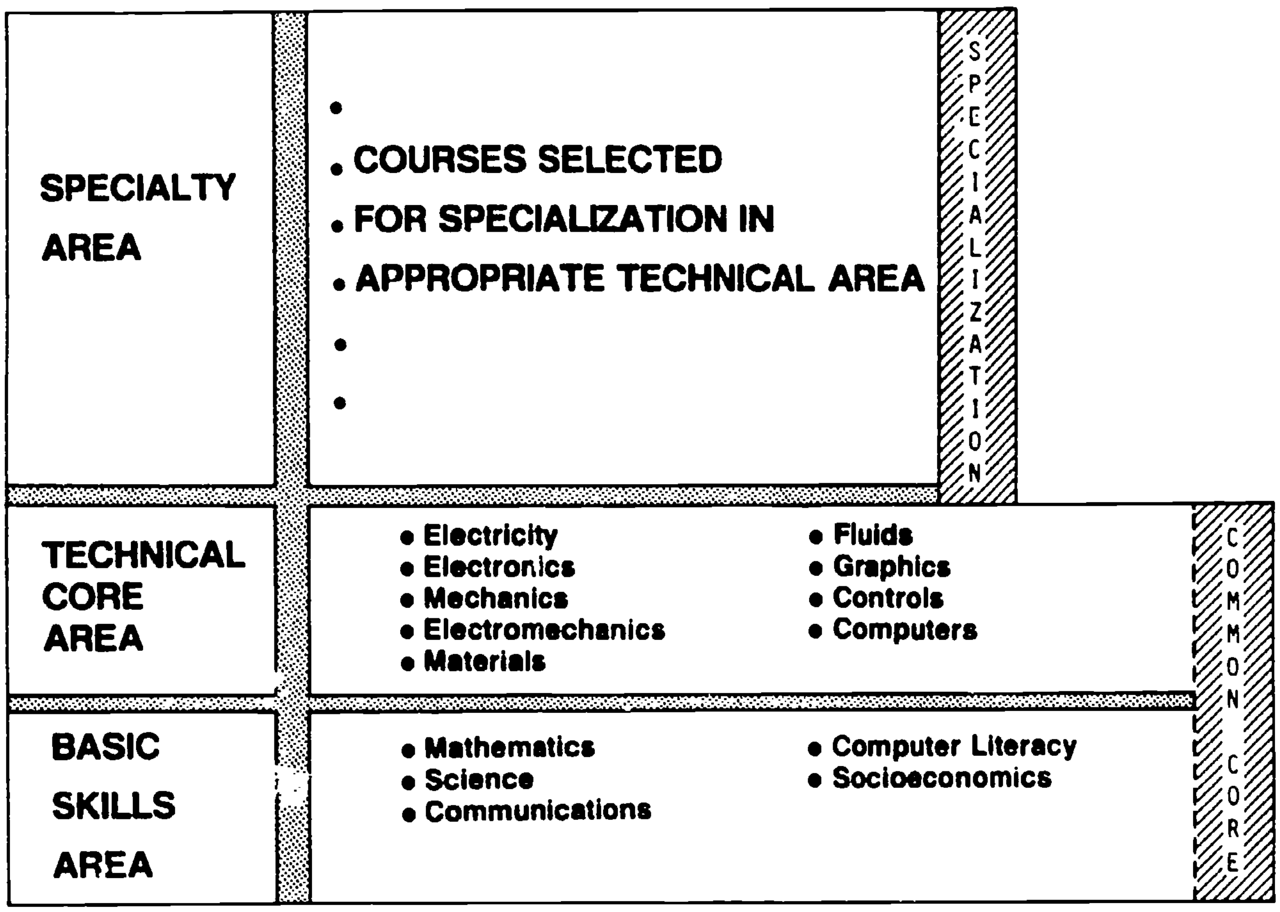

Figure 4a

Postsecondary Programs
Advanced-Technology Model Curriculum Structure
General Philosophy

SPECIALTY

- Overview of Semiconductor Manufacturing
- SMT-I Wafer Prep, Contamination Control, Oxidation, Diffusion
- SMT-II Photolithography, Wet and Dry Etch
- SMT-III CVD, Thin Films, Metalization, Ion Implant
- Projects in Semiconductor Manufacturing Technology

TECHNICAL CORE

- Applied Industrial Chemistry
- DC and AC Circuits
- Semiconductor Electronics I
- Semiconductor Electronics II
- Digital Electronics
- Mechanical Devices and Systems
- Diagnostic Troubleshooting of Automated Systems
- Vacuums and Lasers
- Vacuums II
- Electronic Test and Instrumentation
- Automated Production Systems
- Applied Statistical Quality Control
- Microprocessor Controls

APPLIED MATH AND SCIENCE

- Algebra
- Trigonometry
- Physics for Technicians I
- Physics for Technicians II

COMMUNICATIONS

- Technical Communication
- Personal Computer Skills
- Group Communication

SOCIOECONOMIC

- Economics in Technology
- Elements of Supervision

Figure 4b

SMT Curriculum Model for Two-year Postsecondary Technology Program

12. Report project progress

Quarterly progress reports were submitted to the Department of Education. This final progress report serves as the third quarter report for 1991. Program updates concerning significant events in the SMT program were sent to the Department of Education Program Officer in a timely manner.

VI. DISSEMINATION

The Technician Training Program has been promoted and information disseminated in eleven educational and industry conferences by CORD and SEMATECH personnel and in a Semiconductor Equipment and Materials International (SEMI) Industry-Education conference by TSTC Chancellor, Dr. Cecil Groves. A major article on the *Transformations* worker retraining program appeared in *Economic Development Commentary*, and the *BSU News Services* placed an article on the Micron worker training program in the *Idaho Business Review*. The book *Tech Prep Associate Degree: A Win/Win Experience*, by Dan Hull and Dale Parnell, describes the *Transformations* curriculum at BSU. Articles tracking progress on the TSTC demonstration course have appeared in six issues of the *NCATC Newsletter*. Several newspaper articles have also appeared.

Due to the very complex nature of SMT, individuals trained and employed in industry will often need and desire to expand their knowledge and capabilities through various advanced training. With this thought, meetings were initiated with Texas A&M University and the University of Texas to develop articulation agreements which would provide continuing education opportunities for persons completing the Associate Degree curriculum.

To establish a broad base of interest and participation in the curriculum development, a coordination and communication meeting was held April 20, 1990, with a number of schools from across the country. These schools expressed an interest in the SMT project. During this one-day meeting, institutions shared their knowledge of semiconductor training, job needs, and retraining needs as they perceived them in their respective regions. The project director explained the work that had been done to date in regard to the project and shared the task analysis.

Educational institutions interested in the project were invited to attend Advisory Committee meetings and workshops on October 9-10, 1990, and February 3-4, 1991, (see section V, part 1). Many of those who were unable to attend requested and were mailed copies of the Technician Training Project Status Report issued at each of the meetings. This interest group grew from 35 to over 60 by May 1991, when the Educational Information Dissemination conference was held.

An Educational Information Dissemination conference was held May 9-10, 1991, at TSTC in Waco with 20 persons from nine institutions in attendance. Participants discussed curriculum implementation at TSTC and toured the Laser Electronics Technology and Semiconductor Manufacturing Technology laboratories. A 235-page Semiconductor Manufacturing Technology Dissemination Conference notebook was issued to all participants. Topics included an overview of semiconductor manufacturing and the program, revised curricula and course outlines, a TSTC process sequence and TSTC implemented curriculum, TSTC proposed curriculum revisions for 1991-1992, implementation guidelines, bibliography, publishers and textbook review.

In addition to the communication with a number of schools and businesses, project visibility was enhanced through a press conference and project briefing for Senator Phil Gramm on Saturday, March 17, 1990. Press notices are found in Appendix K. On May 2, 1990, Mr. Tom Liberty of SEMATECH and the project director appeared on a national teleconference relating to Electronic Technology Programs for the '90s. On March 9, 1990, Mr. Liberty addressed the National Association of Industry Specific Training Directors and described the SMT project. More than a dozen states were represented, and the participants expressed great interest in the project.

Promotion of the SMT program continued throughout and beyond the contract period. Dr. Walter Edling, CORD Vice President for Programs, presented the SMT curricula, partnering efforts, and other sub-projects at the Semiconductor Research Corporation Competitiveness Foundation Workshop, May 30-31, 1991, in Troy, New York; at the NCATC Fall conference, November 7-9, 1991, Waco, Texas, and the NCATC Summer conference, June 21-23, 1990, Camden, New Jersey; and at other conferences. An Education Council meeting at the Applied Materials Training Department in Austin, Texas, on November 18, 1991, was the site of a two and one-half-hour presentation and discussion of the SMT curriculum given by CORD Research Associate, Mr. Bob Thompson.

The BSU/Micron *Transformations* worker retraining program was presented by Dr. Edling to many groups including the National Conference for Occupational Education for the National Council on Community Services and Continuing Education October 21, 1991, in Corpus Christi, Texas, by CORD Research Associate Alan Sosbe who aided BSU in the Micron program. A complete listing of presentations and articles in national publications is found in Appendix L.

VII. EVALUATION

As specified in the project proposal, CORD employed an outside evaluator to assist CORD and SEMATECH in determining program effectiveness and evaluate how well the four main project goals have been achieved. Each of the pilot training sites was visited by the evaluator to examine enrollment, student learning gains, and continued participation rates in both pilot courses. Dissemination efforts were also examined and suggestions for improved effectiveness and future directions will be put forth. The evaluation report by Dr. Glen I. Bounds, Provost, Bill Priest Institute for Economic Development, Dallas Country Community College District, Dallas, Texas, is found in Appendix M.

Overall, the program has been very successful. The SMT students at TSTC have completed four of seven quarters, but the first TSTC graduates will not be received into the job market until June 1992. Semiconductor manufacturers have sent representatives to TSTC to interview and evaluate the mid-course SMT students and the reports are favorable. SEMATECH has been hiring Laser/Electro-Optics graduates from TSTC at Waco and Instrumentation Technicians from TSTC at Harlingen, and each year they and other semiconductor manufacturers come to the campuses to interview and hire.

Student recruitment is a priority. TSTC is committed to the success of the program, but no school can continue a high technology program without an adequate number of students. A program of this magnitude and caliber would expect to have from 40 to 60 students in various phases of the program. Additional brochures explaining what semiconductor manufacturing is and its importance as a career could be developed to mail to high school counselors. Portions of the prospective-student package could be couched in less technical language, TSTC counselors could travel to Texas high schools to speak on and hold discussions about new programs, and videos such as *Silicon Magic* from SEMI and the TSTC-developed video could be shown.

The program at TSTC has been sharing the vacuum laboratory with the Laser/Electro-Optics groups which perform everything from pump teardown to metallization experiments. Scheduling problems arose when the SMT students who were ready for an experiment found that the metallization system either needed repairs or was scheduled for demonstration by the laser groups. The second problem with this arrangement is that the vacuum lab does not have a cleanroom air filtration system because of the dirty-type experiments performed in the vacuum lab. Carrying clean wafers into the dirty vacuum lab for metallization will certainly cause contamination, low yields, and possible experiment failure. This is not solely bad, as low yields and yield improvement are problems that students need to learn to struggle with. To avoid scheduling problems with shared equipment, the SMT group should eventually obtain its own metallization system.

The worker retraining was successful enough for Micron Technology, Inc. to continue training of the 19 graduates and consider training of additional personnel. The grueling schedule experienced by the workers suggests that some further arrangements need to be made for release time from the job while attending classes. The fact that 420 hours of instruction was compressed into 308 hours with only one dropout (due to illness) shows that there is some flexibility in the program, but the absenteeism for some of the shift workers approached 40 percent. One can assume that had the class hours been reduced, attendance would have been higher and, hopefully, learning would have increased. Now that the program has been demonstrated successfully, employers should be urged to be more supportive of employee technical literacy training by allowing flexible time schedules to attend classes.

VIII. CONCLUSIONS

Overall, the Semiconductor Microdevices Training project has been very successful. The SMT students at TSTC have completed four of seven quarters. Semiconductor manufacturers have sent representatives to TSTC to interview and evaluate the students enrolled in SMT, and they report a high interest in the students; the representatives have also made many complimentary remarks regarding the curriculum. The worker retraining program at BSU has been completed, and a majority of the retrained Micron workers have elected to continue their training, either with in-plant classes or with on-campus studies. All primary objectives of the project have been met or exceeded.

A. Achievement of Four Primary Objectives

1. To work with industry experts and educators to design and develop curricula to train semiconductor technicians.

Industry experts were assembled from SEMATECH and its member companies into a Technical Advisory Committee to create and validate a detailed Technician Task Analysis. Representatives from community colleges (NCATC members) along with two more from four-year colleges formed the Curriculum Advisory Committee to provide guidance to design and develop a curriculum based on the survey of industry needs and the Technician Task Analysis.

2. To implement and test the curricula at a technical college that has a track record of working with the semiconductor industry.

SEMATECH has consistently hired graduates of the Laser/Electro-Optics program from TSTC at Waco and the Instrumentation Technician program at TSTC Harlingen and Waco campuses. The first four of seven quarters of curriculum materials have been tested and revised. TSTC has fully implemented the SMT program, making considerable investments in facility renovation and equipment procurement and is committed to continuing the curriculum.

3. To disseminate information on the curriculum and encourage its replication at community and technical colleges throughout the country.

The curriculum has been presented at several NCATC and SMT Technical Advisory conferences and at an Educational Dissemination conference. Conference reports and notebooks have been distributed to many schools and manufacturers that have requested curriculum information. Articles on worker retraining in the semiconductor industry and progress of the SMT Associate Degree program have been published in the *Idaho Business Review*, *Economic Development Commentary*, *Tech Prep Associate Degree: A Win/Win Experience*, and the *NCATC Newsletter*. Professional-quality brochures describing the TSTC SMT program are available and have been sent to many interested community colleges.

4. To create a model for the development of technician training programs for new and emerging technologies.

The process and cooperative efforts between industry, community colleges, a university and an independent consultant that were used to develop the SMT Associate Degree program and the worker retraining program are described in this report. An extensive curriculum guide is being developed and will be available in early 1992.

B. Recommendations

Cost of implementation is always a major factor when any school considers whether or not to offer a new curriculum. This is especially true in the semiconductor field because of the very high cost of the equipment and the cleanliness requirements. TSTC achieved significant cost reduction in their use of solar cell manufacture rather than semiconductors; the identical techniques were used without the need for extreme cleanliness. TSTC also achieved cost savings by utilizing labs designed for other curricula to support SMT. Both of these are very important, and any school should consider these opportunities while contemplating the possibility of offering an SMT program.

The worker retraining at BSU was successful enough for Micron Technology, Inc. to continue training of 16 graduates and to consider offering retraining to additional personnel. The grueling schedule experienced by the workers suggests that some further arrangements need to be made for release time from the job while attending classes.

The fact that 420 hours of instruction were compressed into 308 hours shows that there is some flexibility in the program. Only one student dropped from the class and absenteeism for some of the shift work workers approached 40 percent. One can assume that had either the work or class hours been reduced, attendance in class would have been far greater. Now that the program has been demonstrated successfully with the employed semiconductor worker, employers using this program in the future should be urged to allow more time to attend classes by reducing the working hours.

This project provided for curriculum and course design, not development of student materials. While the outlines are very useful for instructors, there is a near void of student material for this highly sophisticated subject. There needs to be a project funded for the development of the necessary student materials.

C. Impact

While the cost of the laboratory equipment and facilities may prevent a number of schools from implementing the total curriculum immediately, it is expected that several schools will begin with partial implementations as directed by the needs of their local semiconductor manufacturers.

The Harlingen campus of TSTC expects to implement some portion of the Waco TSTC tested curriculum. Schools in Austin, Texas; Portland, Oregon; Boise Idaho; Albuquerque, New Mexico, and other states with semiconductor manufacturing plants have also indicated an interest. Applied Materials, Inc., the third largest manufacturer of process equipment for microdevice fabrication, has requested that Austin Community College put in place semiconductor-specific technical core courses and some implementation of the specialty courses to support the new Applied Materials, Austin, Texas, facility by 1993.

APPENDIX A

Semiconductor Manufacturing Technology Project Time Line

Semiconductor Manufacturing Technician Project Milestones

January 1, 1990	Project begins.
February 1, 1990	Employment of project director.
March 1, 1990	Complete preliminary planning with SEMATECH.
April 2-4, 1990	Technical Advisory Committee meeting.
April 15, 1990	Technical Advisory Committee provides detail task list.
April 20, 1990	Educational Coordinating Committee meets.
May 1990	Technical Advisory sub-Committee meetings at SEMATECH: Task validation and examination.
May 2, 1990	Initial curriculum design by the CORD and TSTC. Initial task list edited, printed and ready for dissemination.
May 7, 1990	Task list validated by SEMATECH and industry experts.
May 15, 1990	TSTC submits preliminary curriculum to state.
June 3, 1990	Task analysis and proposed curriculum sent to Advisory Committee members and school representatives for review and suggestions.
August 15, 1990	Texas Higher Education Coordinating Board gives TSTC approval to begin course in semiconductor technology.
August 27, 1990	Request to SEMATECH CEO for greater SEMATECH involvement by CORD.
September 4, 1990	Instructor Employed at TSTC. Pilot program begins.
October 5, 1990	Task analysis ready to publish.
October 9-10, 1990	Technician Training Project Status Report to Semiconductor Technician Training workshop in Austin, Texas.
December 3, 1990	Curriculum writer employed at the CORD.
January 7, 1991	Micron Technology, Inc, agrees to pilot retraining program in conjunction with BSU.
February 1, 1991	Third-party evaluator hired to review demonstration courses and materials at TSTC and BSU sites.
February 4, 1991	Second Technician Training Project Status Report includes summary of survey responses.

March 4, 1991	Worker training courses begin at BSU with Micron Technology's workers.
April 1991	Chemistry writer develops Workplace Chemistry outline as recommended by advisory committee.
April 19-20	Educational Coordinating Committee meeting held at SEMATECH in Austin, Texas. Proposed project structure developed.
April 29, 1991	Request no-cost modifications and for four-month no-cost contract extension to design/develop specific courses and implement worker retraining.
May 9-10, 1991	Educational Dissemination Conference and Advisory Committee meets at TSTC.
June 30, 1991	Scheduled end of contract.
June 29, 1991	No-cost contract extension granted through October 31, 1991.
August 5, 1991	Worker training courses end at BSU with Micron Technology's workers.
October 31, 1991	Demonstration course outlines received from TSTC. Project complete. Semiconductor Manufacturing Technician course continues into second year at Texas State Technical College.

APPENDIX B

Technical Advisory Committee Membership List and Letter

CORD CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

601 C Lake Air Drive Waco, Texas 76710 Telephone (817) 772-8756

March 23, 1990

Technical Advisory Committee

Dear FILE:

Thank you very much for agreeing to serve on the Technical Advisory Committee for the Semiconductor Manufacturing Technology Curriculum development project. We have every reason to believe that the results of this project will provide major benefits to the effort to increase the competitive posture of the U.S. semiconductor industry, and your experience and advice are critical to that success.

The Advisory Committee meeting is scheduled for Tuesday and Wednesday, April 3 and 4 at the SEMATECH headquarters in Austin. As you can see from the enclosed agenda, the meeting will begin at 8:30 A.M. on April 3. Therefore you will need to arrive the evening of April 2, if you are coming from out of town. Special SEMATECH rates of $60 are available at the Wyndham hotel, which is convenient to the SEMATECH facilities. A map and additional information are enclosed.

We are particularly interested in looking forward to the decade of the '90s and designing training programs which will match the emerging needs of the chip industry as the technology continues its rapid evolution. This effort at projection is far more difficult than simply observing current and past practice, and it is the area where your experience and judgment will be especially critical.

While we will present some information about the project and some "strawman" exhibits to stimulate discussion, the major purpose of this meeting is to hear your ideas and perspectives in regard to what technicians need to know and do in semiconductor manufacturing and the type of training and retraining needed to prepare and develop a world-class, competitive workforce in the industry. Therefore, we encourage you to come prepared to share any ideas and information which may contribute to the discussion.

Enclosed are an agenda for the meeting, a brief description of the project and a preliminary list of the participants. Also enclosed is a Proposed Manufacturing Technician Task Listing prepared by Tom Liberty and his associates at SEMATECH. This is intended to be a stimulus for thinking and discussion and you should feel free to add or modify as you see fit.

Please call Walter Edling or Barbara Grayer at (800) 231-3015 or (817) 772-8756 (in Texas) to confirm your attendance. Thank you again for agreeing to participate, and we look forward to a productive meeting.

Sincerely,

Tom Liberty
Director, Technical Educational Programs
SEMATECH

Walter H. Edling, Ph. D., P. E.
Director of Programs
CORD

WHE:sh
Enclosures
bcc: Robert Millar, DOE
William Cox, TSTI
Bert Marcom, ACC
Don Goodwin, TSTI
Cecil Groves, TSTI

SEMICONDUCTOR MANUFACTURING TECHNOLOGY TECHNICAL ADVISORY COMMITTEE

Jerome Beckman
Hewlett Packard
815 14th Street
Loveland, Colorado 80537

Andre Blanc
Director of Manufacturing Technology
Harris Semiconductor
MS 58-74
Building 58, Palm Bay Road
Melbourne, Florida 32905

Dick Blanchard
IXYS
2355 Zanker Road
San Jose, California 95131-1109

Bill Brennan
AMD
2706 Montopolis Drive
Austin, Texas, 78741

Joe Carroll
IBM
1000 River Road
Essex Junction, Vermont 05452

Wayne Cronin
Motorola
10803 Greymere Court
Austin, Texas 78739

Bernard Fay
Semi/SEMATECH
2706 Montopolis Drive
Austin, Texas 78741

Norman F. Foster
SRC
Suite 300, Building 4401
79 Alexander Drive
P.O. Box 12053
Research Triangle Park, North Carolina 27709

John Georgick
Texas Instruments
MS 385
13353 Floyd Road
Dallas, Texas 75265

Jan Harris
NSC
MS 4000
3333 West 90th South
West Jordan, Utah 84088

L.C. "Bud" Harris III
Director, Business Development
Business and Technology Center
Austin Community College
5930 Middle Fiskville Road
Austin, Texas 78752

Jim Laibl
Human Resource Manager
Harris Semiconductor
MS 62-003
P.O. Box 883
Melbourne, Florida 32901

Tom Liberty
IBM/SEMATECH
2706 Montopolis Drive
Austin, Texas 78741

Richard Moore
Associate Dean of Instruction
Texas State Technical Institute
3801 Campus Drive
Waco, Texas 76705

Jerry Muff
NSC
MS 2C43
111 39th Avenue Southeast
P.O. Box 5000
Puyallup, Washington 98374

Vijay Persuad
Harris Semiconductor
2706 Montopolis Drive
Austin, Texas 78741

John Waite
NSC
MS 27-100
P.O. Box 58090
Santa Clara, California 95052-8090

Skip Weed
SEMATECH/Motorola
2706 Montopolis Drive
Austin, Texas 78741

Keith R. Whiteside
Training and Education Semiconductor Group
Texas Instruments
MS 3909
7800 Banner Drive
P.O. Box 650311
Dallas, Texas 75251

Ron Williams
NCR
2001 Danfield Court
Fort Collins, Colorado 80525

Cliff Wilson
IBM
1000 River Road
Essex Junction, Vermont 05452

CORD Staff
    Daniel M. Hull, President and CEO
    Walter H. Edling, Director of Programs
    Barbara Grayer, Secretary
    Kay Liston, Executive Assistant
Center for Occupational Research and
  Development
601 C Lake Air Drive
Waco, Texas 76710

APPENDIX C

?reliminary Task List

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CORD/SMT
Edling/Lovett
bg/October 5, 1990, 1:48 PM

Technician Task List

PROCESS: PHOTOLITHOGRAPHY

Basic Functions	Detailed Job Tasks	Knowledge Required
I. Operations		
A. Checks status of parts (materials) inventory	• Reviews product type and counts • Reviews material inventory and requirements	• Wafer characteristics • Wafer identification parameters, coding —Wafer flats —Crystal orientation (1,1,)(1,0,0) —Semiconductor equipment and materials —Institute (SEMI) code —Use of colimated light and x-ray —diffraction inspection • Metallurgy of crystals —Crystal structure —Crystal growth —Crystalline planes —Solid solutions —Impurities and doping • Needs to know how to use inventory control system to look ahead and group lots of similar type to minimize number of set-ups • Details of photolithography process
B. Determines day's priorities	• Reviews manufacturing specifications	• Reading and interpretation of production specifications • Checks equipment status for any repairs or adjustments on previous shift
	• Reviews manufacturing schedules	• Reading and interpretation of production schedules
	• Establishes work priorities and scheduling	• Communicates with previous shift for passdown of information • Basics of manufacturing scheduling • Basics of MRP

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions

C. Checks/adjusts equipment setting for desired operation

Detailed Job Tasks

- Reviews manufacturing specifications
- Adjusts, verifies all operating parameters

Knowledge Required

- Fundamentals of photochemistry
- Fundamentals of inorganic and organic compounds
  —Effect of time
  —Effect of light wavelength
  —Effect of temperature
  —Polymerization
  —Physics of light
  —Frequency wavelength, energy
  —Diffraction effects
- Coating and film technology
  ·Surface preparation and adhesion
  —Solvents used
  —Film thickness
  —measurement techniques
  —Porosity
- Properties of liquids
  —Viscosity units and measurements
  —Density
  —Specific gravity
  —Pressure
  —Flow measurement
  —Flash point
- Properties of gases
  —Density
  —Pressure
  —Temperature
  —Gas laws
  —Particle pressures
  —Flow measurement

Technician Task List

PROCESS: PHOTOLITHOGRAPHY

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
D. Prepares substrates as required by specifications	• Washes wafers using scrubbers, high pressure water • Spin dries • Desiccates • Dehydration bakes —Low temperature bake —High temperature bake —Vacuum bake	• Cleans used to promote adhesion or remove particulates collected in storage boxes. • How to look for wafer spots left from incomplete dry. • Why wafers must be raised above 100° C to remove monolayers of water • Physics of rotation —Angular speed, acceleration —Centrifugal forces —Balance • Physics of heat —Temperature and its measurement —Insulation, Thermal conducting —Radiation, conversion, conduction —Hydrophilic/hydrophobic conditions —Construction of bakery ovens
	• Inspect for hydrophilic/hydrophobic condition	• Binocular Microscope angle measurement tech using drop water • Meaning of hydrophobic and hydrophilic

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
E. Vapor-primes substrates	• Loads, adjusts spin-coaters for priming • Verifies liquid primer supply and specs • Verifies vapor primer supply and specs • Vacuum bakes primer	• Properties of primer liquids and gases --Basic chemistry —Physical properties —Safety requirements —Sources and handling • Operational details of primer application —Methods —Adjustments —Quality checks • Reason for primer • Hazards from material • Oxygen contamination of vapor prime • Need to exceed 100°C, conductive vs radiant heat • Change of water surface state to hydrophobic

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
F. Coat wafers with photoresist	• Loads, adjusts spin-coater for resist application • Verifies resist type and supply • Monitors specified process variables	• Types of resist application (static vs dynamic) • Different viscosities of resist • Hazards of chemicals • Importance of correct temp & humidity in room • How exhaust flow into cup can change resist thickness profile • Reason for Edge Bead Removal • Optical EBR • (Top & Bottom EBR techniques) • Properties of photo resist materials —Basic chemistry —Physical properties —Sensitizers —Solvents —Negative positive —Oxygenation —Additives —Safety requirements —Sources and handling
G Soft bakes wafers	• Loads, adjusts bake process —Convection ovens —Vacuum ovens —IR ovens —Microwave ovens —Conduction belt ovens	• Reason for softbake • What happens if temp is either too high or low • Types of softbake ovens • Operational details of application devices and baking processes —Methods —Adjustments —Quality checks · Coverage · Thickness · Pinholes

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions

H. Exposes wafers

Detailed Job Tasks

- Loads, adjusts stepper
- Verifies, loads proper masks and pellicles
- Operates and monitors stepper
- Monitors, adjusts exposure parameters
  —Intensity
  —Time
  —Use of integrator

Knowledge Required

- How a big a stepper field prints
- Different versions of reticles
- Particle size and pellicle stand off distance
- Check stepper performance against "Mother" machine grid
- How positive and negative resist react to light
- Reasons for CP and Overlay variance
- Global vs field by field alignment
- How a stepper "MAPs" a wafer
- Construction and operation of stepper
  —Adjustments
  —Routine maintenance
  —Preventative maintenance
  —Operating steps
- Masking processes
  —Single
  —Double
  —Multiple layers
- Planarizing
- Physics of exposure sources
  —Ultraviolet
  —Electronic beam
  —Diffraction
  —Resolution
  —Yellow light, spectral response
- Dispense mechanisms
  —Static
  —Dynamic
  —Moving
  —Drawback

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
H1. Post exposure bake	• Loads adjust bake process	• Reduces standing waves • Stabilizes • Increases adhesion
I. Develops photoresist	• Loads, adjusts developer process as required —Immersion —Spray —Plasma	• Immersion used for small geometrics and long develop times • Spray for quick turn around of wafers and automation • Plasma develop for exotic multilayer resist processes • Developer properties and chemistry • Developer processes —Immersion —Spray —Plasma —Puddle • Inspection and quality control parameters —Under/over develop
J. Hard bakes wafers	• Loads, adjusts bake processes —Vacuum —Convection —Infrared Radiation —Microwave —Hot plate	• Physics and construction of baking processes (See above) • Reason for hardbake & oventypes, proximity baking on hotplates

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
K. Measures and inspects wafer per specs	• Counts defects	• Types of measurement tools (KLA, SEM) • Familiarity with measurement devices and use —Visual —Microscopic —Critical dimensions —Edge distension,bridging, edge quality —Resist lifting —Scratches —Contamination —Pinholes
K1. Wafer inspection	• Measure critical dimensions	• Optical Tools and intensity/reflectivity profiles • Engineering spec vs production capability • Spore vs line profile • Entire CMOS, NMOS • Bipolar flow of wafers being processed to connect defect seen with correct process step • Is the defect at the current level or previous?
L. Transmit wafer to etch	• Measure overlay	• Engineering spec vs production capability • Familiarity with TPC Methods

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions

II. Maintenance
   A. Calibrate and/or adjust photolithography equipment

Detailed Job Tasks

- Adjust exhaust
- Adjust spin speed
- Adjust dispensing quantity
- Adjust bake temperature and time
- Adjust light intensity and distribution•
- Adjust alignment/spacing of stepper
- Perform other stepper adjustments

Knowledge Required

- Use of strobe
- Volume & weight measurement
- Different wavelengths of light in equipment
- What is a stepper "Baseline"
- Global vs field by field parameters
- Magnification
- Trapezoid
- Focus within a field can vary
- How one stepper can be matched to a group
- Lens vs stage parameters for overlay adjustment
- Mechanical knowledge
  —Construction of photolithography equipment
  —Required calibrations
  —Required adjustments
  —Maintenance procedures
    - Routine
    - Preventative
    - Major
- Knowledge of physics
  (Covered above)
- Knowledge of chemistry
  (Covered above)
- Knowledge of crystalline metallurgy
  (Covered above)
- Knowledge of electricity/electronics
  —Circuit analysis to board level
  —Systematic trouble-shooting procedures
  —Ability to read, interpret electrical specifications, circuit diagrams, and

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
		functional diagrams —Ability to use state-of-the-art analysis equipment - VTVM - Osilloscope - digital • Knowledge of vacuum systems To level of trouble shooting components • Knowledge of pneumatic systems To levèl of trouble shooting components
B. Perform preventive (scheduled) maintenance	• Change lamp • Clean chuck • Lube transporter • Level stage • Adjust automatic water handler	• Knowledge of hydraulic systems To level of trouble shooting components • How a lamp's life is reduced when it's shut off • Removal of finger prints from lamp • Lamp centering adjustments & uniformity • Knowledge of micro controllers To major component level • Diode adjustments for AWA sensing
C. Troubleshoot and repair equipment	• Change, wipe down/flush wetbench filter • Change microcontroller • Change camera • Change/bake out SEM gun tip • Restore vacuum to spin chuck • Correct misalignment in dispense arm • Repair stepper	• Camera gain for various substitutes • Adjustments to SEM for focus adjustments • Reasons for "COMETS" at coat

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions

III. Train others to do tasks in 1 and 2

Detailed Job Tasks

- Lays out training materials and steps for others
- Explains functions to others
- Checks performance of others during training

Knowledge Required

- Able to organize and write out technical information
  —Terminology
  —Spelling
  —Basic grammar, punctuation
  —Perceptive writing
  —Outlining
  —Citations (references)
- Oral presentation skills
- Able to communicate technical information verbally
  —Prepare presentations
  —Prepare support documents (diagrams,
  —sketches, etc.)
- Able to understand the basic teaching/learning process, and empathize with learners
- Patience, tolerance
- Understands need for repetition, close supervision during learning

Technician Task List

PROCESS: PHOTOLITHOGRAPHY

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
IV Multitasking and workload management	• Seeks ways to combine and coordinate tasks • Offers suggestions for operational improvement • Provides written and verbal reports • Presents reports and technical summaries verbally	• Looks ahead for similar lots • Minimizes tool set-ups • Coordinates with co-workers • Monitors SPC & tool operation and looks for trends • Shift to shift passdowns • Organization of lot & equipment status • Report writing, making charts & tables • Experienced in working in teams or groups —Willing to share information —Willing to ask for help or ask questions —Willing to accept advice —Willing to compromise views —Aware of creative thinking techniques
V Improve cycle time and yield	• Performs trials (experiments) of different process steps and adjustments • Records and analyzes results in terms of yield and cycle time improvement • Tracks, records and analyzes basic defect patterns	• Knowledge of experimental methods • Able to record and organize data (Charts, graphs, etc.) • Able to interpret data and relate to hypotheses • Runs design of exp to find optimal equip. parameters • Looks for tool to tool differences • Designs own job to be more efficient • Handles wafers as little as possible (minimal transfers)

Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD

Basic Functions	Detailed Job Tasks	Knowledge Required
I. Operations		
A. Verify status of product inventory	• Log lot on COMETS • Verify Number of Wafers, Process STEP, look for FCMs • Look for KanBan TAG	
B. Tool status	• Verify up for Process • All systems in SPEC	
C. Loading monitors	• Pre measure Wafers for stress • Loan monitors into cassette according to SPEC • Flat orient Wafers on FLAT	
D. Loading software recipe and verifying recipes	• Load recipe required in finder microspec • Check sequence and recipe • Enter lot number and match sequence • Place Wafers on machine	
E. Push run		
F. Respond to alarms	• Verify problem • Unload Wafers if req'd	
G. Unload wafers		

CORD/SMT
Edling/Lovett
bg/October 5, 1990, 1:48 PM

Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
H. Measure stress, thickness	• Measure thickness on prometrix • Measure stress on FSM • Measure Refractive INDEX	
I. Visual inspection	• Look for particles in bright light • Look for deformities in film • Microscope inspection	
J. SPC: Input data to RSI	• Log into RSI • Run SPC program • Input data • Check for points out of control	
K. Input data to COMETS Log lot out	• log lot out on comets:	

Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
II. Maintenance		
A. Routine checks		
1. Particles	• Scan Wafers on tencor • Run Wafers on machine • Scan Wafers on tencor • Verify particle counts are in SPEC	
2. Leaks	• Run lear rate routine • Verify in SPEC • Troubleshoot leak w/leak checker • Verify baratron reading	
3. Flow controller calibrations	• Run AFC calibration routine	
4. Facilities	• Read water flow, temperature, exhaust flow gauges • Adjust valves so gauges read in SPEC	
5. Pump operation	• Check oil level • Check pumping speed: Time To Pump chamber down - shut off ballast valve	
6. Film Quality	• Run metal evaporator • Run electrical test, place WAFER on probe station, run program	

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Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
B. Repair		
1. Chamber cleans	• Vent chamber using routine • Wear safety equipment • Wipe chamber • Visual inspection of progress kit • Pumpdown chamber • Manually flow gauges & set pressure	
2. Loadlock wipedowns		
3. "O"ring inspection/replace	• Remove Orings	
4 Robot calibrations	• Follow routines	
5. Pressure calibration	• Follow routines	
6. Flow controller zero	• Follow routines	
7. Clean pump screens & forelines	• Use DVM's, o'scopes & schematics to troubleshoot system • Shut off pumps & clean screens, & foreline	
III. Engineering		
A. SPC	• Prepare chemicals & monitors for stripping	
B. Identify equipment operation/baselining equipment		
C. Find causes for out of control processes		
D. Training		
E. Prepare/present report		
IV Other		
A. Stripping monitors		
B. Ordering spare parts		

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
I. Observe safety precautions A. High voltage	• Awareness	
B. RF C. High vacuum	• Volume, Pressure	
II Operations		
A. Check gauges, controllers	• Read, adjust record values from meters, instruments	
B Check gas flows, power, temperature	• Read, adjust record values from software or mechanical	
C. Verify status of product inventory	• Review inventory, strategize process efficiencies/workload; check supplies inventory	
D. Load monitors	• Review, select, edit, recycle-handle cassettes, transfer wafers, insert cassette	
E Monitor process and respond to alarms	• Check instrument values, read & record	
F. Record process variables	• Record KWH, cap time, argon N2, flows, temperatures, pressures, power	
G. Unload wafers	• Remove cassette, remove wafers, load into carrier	
H. Measure film quality	• Evaluate resistivity, performance, thickness, XRF & profilometry, alloy emlest movile, or contamination, particles, stress	
I Perform visual checks	• Evaluate grand size, defects, specularity, color	
J. Determine if process is within tolerance (spec)	• Plot value on control chart, review VS spec, evaluate control chart	
K. Record date on product	• Record measurement results in database, start/end times	

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
L. Make process corrections	• Adjust by time, recipe parameters, minor adjust repair; convert new files	
M. Follow flow chart	• Notify customer of incoming inventory, communicate process discrepancies	
III Maintenance		
A. Power-up electronics	• Turn breakers on check visual over is on to controllers, reset reboot computer install floppy disks, initialize SKM; verify vacuum conditions	
B. Reset controllers	• Check temperature, status of pump, base pressure, value configuration/status, turnon	
C. Regenerate pump-down curve (vacuum)	• Check temperature, clean poppett valve start compressors, check temperature, open valves/configuration • Record pressure over time internal • Select program, initialize values, verify values, calculate partial pressures, make decision • Change cooling water verify inventory clean shans, tools, record status and values	

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions

D. Evaluate RGA values or spectra
E. Remove, clean, align, rebuild mechanical wafer holders
F. Vent vacuum chamber
G. Remove shields and targets
H. Clean chambers and shields
I. Install clean shields and target
J. Remove, clean, inspect, replace, reinstall "O" rings

Detailed Job Tasks

- Adjust valves turn on N2 remove/screws/shields/target
- Vacuum and clean, inspect cleanliness
- Mix chemicals, install program, position shields, implement clean program, evaluate resistivity of wafers, dry shields, inspect shields inventory sharp
- Install shields/screws: Solvents, Cylinders, Flow Dynamics, DVM, MSe of gauges, instruments
- Inspect quality
- Place probes on target, take measurement, report
- Remove shields, report K, re-install shields, report K

Knowledge Required

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
K. Check target short-to-ground		
L. Troubleshoot short		
M. Calibrate RF generation and 20 KW power supply		
N. Check wafer handling, alignment, cleanliness		
O. Rebuild, replace, reinstall valves		
P. Troubleshoot electronic controlling boards		
Q. Trace electronic, plumbing, vacuum schematics, pneumatics		
R. Perform leak check		
S. Calibrate MFC (mass flow control)		
T. Keep maintenance log		
U. Calibrate heater controllers		
V. Perform chemical cleans on deposited parts		
W. Charge and qualify gas bottles, lines		
X. Perform computer and system diagnostics		
Y. Check microswitches, relays, sensors, IV's		
Z. Coordinate supplier support, spare parts		
a. Rebuild cathodes, recheck		
b. Align chamber		
c. Check ground		
d. Check water resistivity		
e. Calibrate pressure transducers		
f. Operate vacuum manually		
IV. Process technician functions		
A. System requalification		
B. Monitor CV plots		

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required

C. Monitor SPC controls and adjust
D. Measure resistivity
E. Analyze film composition, step coverage groove size, reflectivity
F Waste process operation specs
G. Adjust cathode magnets, and electric fields
H. Measure and evaluate electro-migration
I. Maintain relations with up- and down-stream process steps. Determine customer needs. (Understand requirements)
J Characterize, define process tolerances
K. Design perform, analyze, conclude, report experiments
L. Prepare, analyze equipment performance reports
M Implement SPC
N. Generate troubleshooting guide
O. Reduce defect densities, increase yield

V Other Functions
A Train others
B Prepare, present reports
C. Participate in team activities, problem solving
D. Observe cleanroom practices
E. Monitor utility usage and spare part use
F. Participate in personal development activities

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Technician Task List

PROCESS: PLASMA ETCHING

Basic Functions	Detailed Job Tasks	Knowledge Required
I. Observe safety precautions A. High voltage B. RF C. High vacuum		
II. Operations A. Checks status of parts (materials) B. Determines priorities	• Reviews product type and count • Reviews material inventory and requirements • Reviews prior shift pass downs • Ensures clean wafer boats • Reviews manufacturing specifications • Reviews manufacturing schedules • Establishes work priorities and scheduling	
C. Verifies etch system functionality	• Verifies chamber base pressure • Performs slow calibrations • Performs partial pressure test • Performs particle test • Performs etch rate test • Enter passive data from system test procedures into data base and determines if system performance specification has been met • Takes appropriate action based on the system test results —Trouble shoots and corrects problems —Notifies engineering, ect...as indicated	• Basic plasma physics • Basic chemistry • Basic math
D. Etches send ahead wafers	• Optically inspect • Take appropriate action • Verifies process recipe	
E. Observe and control system operation	• Monitor time to etch endpoint • Monitor shape of etch endpoint & curve • Respond to systems alarms	

Technician Task List

PROCESS: PLASMA ETCHING
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
F. Inspect wafers at post etch	• Inspect wafers optically • Take appropriate action	
G. Perform lot tracking	• Move lot on comets • Enter appropriate data and comments	
H. Moves lot (physically)	• Moves lot to next operation and location	
III. Maintenance		
A. Clean work station	• Wipedown	
B. Clean process chamber	• Vent etch chamber • Remove chamber parts • Clean chamber parts • Install clean chamber parts • Clean chamber • Observe safety regs	
C. Conditions etch chamber	• Loads wafers and runs conditioning and seasoning recipes	
D. Responds to system failures	• Manipulate system using 'manual' commands • Trouble shoots	
E. Check cooling unit water level		

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Technician Task List

PROCESS: METROLOGY

Basic Functions	Detailed Job Tasks	Knowledge Required
I. Operations		
A. Optical film thickness measurements	• Execute programs	• Computer knowledge (General)
	• Record data	• Accurate transcription of results
	• Load/unload wafers	• N/A
	• Enter data into Vax	• Computer knowledge (General)
	• Alignment of patterns	• Microscope operation
B. Thin film resistivity Measurements	• AS ABOVE	• AS ABOVE
C Optical Critical Dimension Measurements	• AS ABOVE	• AS ABOVE
D Scanning Electron Microscope Critical Dimension Measurements	• Execute programs	• General computer knowledge
	• Record data	
	• Load/unload wafers	
	• Enter data into Vax	• General computer knowledge
	• Alignment of patterns	• SEM Theory & operation
	• Operation of S.E.M.	
II. Management of Activities, Priorities	• Review manufacturing schedules, inventory	• General computer knowledge
	• Make decisions on minute-to-minute, & hour-by hour activities	• Basic industrial engineering knowledge
III Maintenance		
A Perform scheduled maintenance		
B. Trouble shoot & determine problem sources		
C. Repair problems		

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Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD

Basic Functions	Detailed Job Tasks	Knowledge Required
I. Observe safety precautions		• Electricity
A. High voltage		• Chemical safety
B. Hazardous chemicals		• Gas handling and safety
C. High pressure toxic gases		• Vacuum technology
D. Vacuum systems		• Basic physics: heat
E. Elevated temperatures		• Industrial safety
F. Facility evacuation procedures		
II. Operations A. Check status of furnace 1. Process gas supply	• Monitor status of gas cabinet, upstream valves, pressure gauges, mass flow controllers, exhausts, burn-box	• Basic physics: Flow, pressure, temperature, combustion, heat, kinetic energy
2. Temperature zones	• Monitor power delivered to zones and corresponding temperature offsets • Check autoprofile status	• Basic physics: Temperature, heat conduction, convection, radiation, Joule Heating, Ohm's Law, thermoelectric effect
3. Robot and elevator	• Verify status and coordinates	• Basic computer operation • Analytic geometry, Cartesian coordinates
4. Upstream computer	• Monitor system status • Verify communications channels • Reboot computer system	• Basic computer operation • Ability to understand complex systems
B. Checkstatus of metrology tools		• Basic physics: Optics
1. Laser/light source	• Verify laser/light source operation	
2. Focus/alignment	• Check system focus/alignment	• Basic physics: Optics • Geometry
3. Control computer	• Reboot computer system • Change hard disk cartridges	• Basic computer operation
C. Check lot inventory		• Elements of industrial engineering
1. Kan-ban,JIT WIP	• Determine line status and status of inventory queues	• Elements of production management • Basic economics
2 Status in Process Control Computer (COMETS)	• Review lot status/history • Review factory communication messages	• Basic computer operation • Understanding of Electronic Mail and Word Processing

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Technician Task List

PROCESS: OXiDATION/DIFFUSION/LPCVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
D. Check test water inventory	• Refer to wet cleans tasks	
E. Check status of preclean tools		
F. Review process control charts	• Access SPC charts • Identify out-of-control conditions	• Statistical process control • Basic probability and statistics • Basic economics
G. Determine day's priorities	• Operate machine	• Machine operation
H. Adjust and/or test tools	• Perform subset of Basic PM's	• See under "Maintenance"
I. Log in operation in Process Control Computer (COMETS)	• Operate VAX terminal	• Basic computer operation • Understanding of process shop floor computer system
J Perform preclean operation	• Refer to wet clean tasks	
K Load material handler	• Operate machine	• Machine operation
L. Download process recipe from upstream computer (APEX)	• Operate Apollo workstation • Initiate data communication between APEX and furnaces	• Basic computer operation
M Begin process run	• Operate machine	• Machine operation
N Monitor run	• Operate machine	• Machine operation
O Unload material handler		
P. Perform Metrology operation	• Operate machine	• Machine operation
Q. Enter data and log out operation in COMETS	• Operate VAX terminal	• Basic computer operation
R Move lots to proper position in fab facility	• Observe deviations from normal machine behavior	• Process physics and chemistry • Electromechanical instrumentation
III. Process troubleshooting/process improvement		
A Design and perform experiments to isolate process problems	• Design and run experiments	• Experimental design
	• Document process problem remedies	

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Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
B. Design and perform experiments to improve process capability and/or operations efficiency	• Observe deficiencies in process or equipment • Observe deficiencies in operational procedures • Design and run experiments • Document improvements	• Process physics and chemistry • Experimental design
IV Equipment maintenance		
A Preventive maintenance	• System rebuild	• Vacuum technology
1 Quartzware change		• Use of hand tools
2. Quartzware clean/inspect	• Operate chemical quartz cleaners	• Basic chemistry
3. Vac system disassembly and assembly	• System rebuild	• Vacuum technology • Use of hand tools
4. Pump oil and filter change		• Vacuum technology
5 Helium leak check	• Operate helium leak detector	• Vacuum technology • Basic electronics
6 Pyro torch assembly	• Rebuild pyro torch assembly	• Gas handling • Basic electricity • Basic chemistry combustion, Stoichiometry
7 Thermocouple adjustment	• Adjust position, connectors, reference circuits	• Electricity, physics: Thermoelectric effect • Properties of materials. metals and alloys
8 Generate test recipes	• Apollo workstation operation	• Computer operation • Detailed understanding of process chemistry and physics
9. Change PBr3, TMB, and TEOS Ampules	• Rebuild, refill, and test liquid source delivery systems	• Vacuum technology • Electricity • Gas handling
10 Service burn box	• Clean and rebuild hydrogen burn box	• Gas handling • Electricity • Basic chemistry combustion, Stoichiometry

Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
B. System repair		
1. Vac system troubleshooting		• Vacuum technology • Electronics (Power and Analog) • Mechanical systems
2. Gas jungle troubleshooting		• Vacuum technology • Electronics • Fluid dynamics
3. Microcontroller troubleshooting		• Electronics (Microprocessors)
4. Upstream computer troubleshooting		• Computer operation • Electronics (Digital)
5. Furnace power electronics troubleshooting		• Heat transfer • Electronics (Power)
6. Main system power distribution and UPS troubleshooting		• Electricity (Facility) • Electronics (Power)
7. I/O module, alarm processor, gas module, and torch control troubleshooting		• Electronics (Analog and Digital)
8. Temperature module and temp control circuitry troubleshooting		• Heat transfer • Electronics (Power and Analog)
9. Liquid source delivery system troubleshooting		• Fluid dynamics • Gas handling • Vacuum technology • Electronics
10. Spare parts coordination		• Electronic Mail and Word Processing
11. Documentation of repair activities		
V. Engineering support		• All of above
A. Organize, run, and evaluate experiments		
B. Update and document process recipes		• All of above
C. Update process and maintenance specs		• All of above

Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
D. Monitor and report on technical aspects of operation VI. Training (Self and Others) A. Identify educational needs and take courses/ask questions B. Learn by doing: Experiment C. Teach what you know to your fellow workers VII. Meetings, reporting, and other group activities		• All of above

Technician Task List

PROCESS: WAFER CLEANING

Basic Functions	Detailed Job Tasks	Knowledge Required
I Operations		
A. Check status of parts (materials) inventory	• Reviews product type • Reviews materials inventory and requirements	
B. Determines day's priority	• Reviews specification • Reviews manufacturing schedules • Establishes work priority and scheduling	• Needs to know how to use inventory control to look ahead and group lots of similar type. • Needs to know critical delay times between processes in order to prioritize processing • check equipment status for any repairs or adjustments communicates with previous shift for passdown of information
C Performs daily process checks on equipment for normal operation	• Reviews manufacturing specs • Performs daily particle and etch rate tests on appropriate process tanks • Performs bath bring-up operations as specified on process instructions	• Is certified to run operations • Able to use metrology equipments (particles counters, film thickness measurement equipments)
D. Chemical safety and handling	• Manually/automatically filling chemical tanks and cannisters	• Must possess full knowledge of chemical handling and safety • Safety gear must be worn at all times during chemical handling • Full knowledge of SEMATECH safety number and shower positioning

Technician Task List

PROCESS: WAFER CLEANING

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
E. Operate pre-diffusion cleaning equipment	• Load/run cleaning equipment • Understand chemistry/recipe of operation • Understand "delay-time" between furnace/pre-clean operations • Understand chemical fill system to equipment • Able to troubleshoot (simple) any equipment problem • Full understanding of process flow (COMETS) system	• Be certified on equipment operation • Understand chemical safety and handling involved with equipment • Able to identify/correct • Process problems related to the chemistry involved
F. Operate automatic photoresist stripping/wet etch equipment	• Load/run equipment • Understand chemistry/recipe of operation • Understand manual sink/automated sink operation • Perform daily process checks (particles/etch rates) • Understanding of process flow system • Full awareness of chemical handling/safety • Solve simple operation/process problems associated with equipment components/robot	

Technician Task List

PROCESS: WAFER CLEANING
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
II. Maintenance		• Chemical safety
A. Calibrate and/or adjust wafer cleaning equipment	• Calibrate/adjust temperature controller	• Knowledge of flow process control
	• Calibrate flow controllers	• Certification on piece of equipment
	• Calibrate motor speed controller	
	• Adjust door seals/lids	
	• Calibrate transducers	• Use of strobe, volume and weight measurements
	• Perform other wet bench/spray processor adjustments	
B. Perform preventive maintenance	• Adjust robot arm	
	• Filter changes	
	• Change/replace plumbing components	
	• Check for leaks	
	• Check for mechanical wear	
	• Check freon content of refrigeration unit	
C. Troubleshoot and repair equipment	• Change process controllers	
	• Calibrate/adjust flow controllers	
	• Check operation of plumbing components	
	• Repair electrical components of equipment	
	• Repair pneumatic/electrical pumps	
D. Training	• Layout training materials and steps for others	
	• Explain functions to others	

Technician Task List

PROCESS: IMPLANT

Basic Functions

I. Operations
   A. Wafer cross section
      1. How a FET operates
      2. Process flow
      3. What the process does
      4. Masking layers (oxidies, nitrates)
      5. Masking with photo resist
      6. Implant damage
      7. Channeling and twist angles and charging
      8. Anneal and activation
   B. Safety
      1. Acids and solvents
      2. Gasses
      3. High voltage
      4. Radiation
      5. Alarm system and evacuation routes
      6. Maintaining Teflon boat integrity

Detailed Job Tasks

- M.S. has completed introductory safety class (given in orientation)
- M.S has completed radiation awareness class
- M.S. understands acid and solvent related safety issues (M.S. is able to recognize acid lines, safety cabinet, litmus paper, safety shower and shower rinse time, reactions of acids and solvents, and applications of implant specific acids and solvents.)
- M.S. understands implant specific gas related safety issues (M.S. is able to recognize implant specific hazardous gases and the dangers of each gas, and knows the location of the gas boxes on each machine.)
- M.S. understands high voltage related safety issues (M.S. is able to point out high voltage areas of each piece of equipment and present related safety precautions)
- M.S. understands radiation related safety issues (M.S. is able to point out "hot spots" on the equipment and can demonstrate radiation awareness)
- M.S. understands evacuation procedures (M.S. is able to follow evacuation routes from both of the implant service aisles as well as the implant bay. M S. must also know how to read the Fab layout and follow evacuation routes for other bays)

Knowledge Required

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
C. Wafer handling 1. Automatic flat finder 2. MGI wafer transfer 3. Vacuum pick-up techniques 4. Clean dirty boat or box 5. Clean work station	• M.S. knows how to clean a dirty box or dirty boat • M.S. understands and practices the correct procedure for cleaning a work station • M.S. understands the importance of, and practices the following wafer handling techniques: 1. Uses the wafer lift, MGI Automatic Transfer, and MGI Automatic Flat Finder when handling boats of wafers. 2. Uses correct vacuum pick-up techniques 3. Does not lean over wafers 4. Does not cross over wafers with body parts 5. Uses correct boat handling techniques 6. Can correctly place wafers in a boat 7. Can correctly place a wafer in a single wafer carrier	

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions

6. Metrology equipment
   A. Thermawave Thermaprobe 300
      a. Technical overview
      b. Operations
      c. Process flow
   B. Prometrix Omnimap R550/e
      a. Technical overview
      b. Operations
      c. Process flow
   C. Tencor surfscan 5000
      a. Technical overview
      b. Operations
      c. Process flow

Detailed Job Tasks

- M.S. can successfully load a desired program onto the Surfscan 5000
- M.S. can operate Surfscan 5000 in manual or capture collection modes
- M.S. knows the correct nomenclature for taking measurements on the RS 50/e and the Thermaprobe 3000
- M.S. can select and use correct files and programs for the RS 50/e and Thermaprobe 300
- M.S. knows control limits and frequency of measurement of the calibration wafers on the RS 50/e and Thermaprobe 300
- M.S. can recall any data point in any RS 50/e or Thermaprobe 300 program
- M.S. can recognize and delete false data points on the Thermaprobe 300 and RS 50/e
- M.S. can bring up Thermaprobe 300 from a power off condition
- M.S. can change Thermaprobe 300 light bulb
- M.S. can recover a wafer from the Thermaprobe 300
- M.S. can back-up Thermaprobe system and data tapes

Knowledge Required

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
D. Implement specific COMETS logging 1. Up/down protocol	• COMETS Logging	
	• M.S. can view the status of any entity in the implant bay • M.S. can view any given spec on COMETS • M.S. can correctly and accurately log any given event for an entity in the implant bay • M.S. can view inventory of production and determine processing for each lot • M.S. can perform continuous process logging • M.S. knows the relationship between COMETS logging and E10-89	
E. R.T.A.'s 1. Peak a. Technical overview b. Operations c. Process flow 2. A.G. a. Technical overview b. Operations c. Process flow	• M.S. can verify and edit the correct implant recipe • M.S. can verify and edit the RTA manual settings • M.S. knows the correct wafer flat orientation in the boat • M.S. can correctly load and unload wafers • M.S. knows what type of boat is to be used on the RTA • M.S. knows why the dummy wafer is loaded in each cassette • M.S. knows the correct annealing temperature for the implant anneal recipe	

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
F. Laser scribe 1. Technical overview 2. Operations 3. Process flow	VI. Laser Scribe • M.S. can perform long- and short-term shutdowns on the laser scribe • M.S. can start the laser scribe from long- and short-term shutdown conditions • M.S. can explain and perform scribing procedures on implant monitor wafers • M.S. can correctly load and unload wafers from the RS 50/e, Surfscan 5000 and Thermaprobe 300 • M.S. can verify RS 50/e probe I.D., successfully change probe head, and perform probe conditioning • M.S. has completed S.P.C. class • M.S. can generate S.P.C. charts for the Prometrix Rs 50/e and the Thermaprobe 300	
G. Implant monitor flow 1. Particle monitors 2. Implant monitors 3. Corrective action response	• Charge monitor	

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions

H. Implant process flow
   1. Phase 1 implants
      a. Steps
      b. Species
      c. Doses
      d. Resist strips

Detailed Job Tasks

- M.S. knows implant process flow, including steps, species, resist strips and approximate poles
- M.S. knows usable particle monitor reject limits
- M.S. knows what to do with particle monitors exceeding usable particle monitor limits
- M.S. knows what type of wafers are to be used as particle monitors
- M.S. knows what to do with monitors for reclaim
- M.S. knows what type of monitor is used for each implant test
- M.S. knows the frequency and specifications for monitoring implant utility wafers
- M.S. knows response protocol for out of control monitors

Knowledge Required

- Safety
- IC manufacturing
- SPC,
- Data entry

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions

I. Operations
   A. Implanter technical overview
      1. Vacuum technology
         a. Roughing pumps
         b. Cryo pumps
         c. Diffusion pumps
         d. Turbo pumps
         e. H.C.I.G.s, T.C. gauges, and other vacuum measurement devices
      2. Introduction to the source chambers
         a. Ionization and how radiation is created
         b. ARC chamber functions
         c. Source magnet
         d. Extraction electrode
         e. Beam steering and focusing
         f. Electron suppression
      3. Introduction to the beamline/flight tube
         a. AMU and analyzer magnet
         b. Post accelerator electrodes
         c. Beam focusing
         d. Beam blow-up
      4. Introduction to the process chamber
         a. Faradays and suppression
         b. Electron showers
         c. Dose processors
         d. Scanning
         e. Beam profiling

Detailed Job Tasks

General

- M.S. can explain the following ion implant functions (refer to figures 1A, 1B, 2A and 2B):
   A. Arc current
   B. Arc voltage
   C. Filament current/resistance
   D. Source magnet(s)
   E. Amu and analyzer magnet
   F. Faraday cups and magnetic electron suppression
   G. Scanning
- M.S. can describe possible causes of the following beam set-up failures. (Refer to figures 1A, 1B, 2A and 2B):
   A. Maximum filament current with no arc current
   B. No filament current
   C. No arc current
   D. The beam current on the NV20A's disk Faraday is considerably greater than the beam current on the flag Faraday
   E. The beam current on the PI9200 shutter (with no adjustments to the beam) is approximately equal to the beam stop beam current reading

Knowledge Required

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
B. Working on line with spec and training documents 1. Equipment set-up and operations a. Explain the workings of the implanters while setting up 2. Skills practice a. Have trainee perform different set-ups on each machine b. Have trainee trouble shoot common implant set-up problems	NV20A • M.S. knows the correct start-up sequence and procedures (refer to sections 5.0, 6.0 and 9.0 of spec IMPP0004). • M.S. knows the correct vacuum pressures (refer to section 6.0 of spec IMPP0004) • M.S. knows the correct set-up sequence and procedures (refer to sections 5.0, 6.0 and 9.0 of spec 'MPP0004) • M.S. knows how to correctly set-up and tune each implant (refer to sections 5.0, 6.0 and 9.0) • M.S. can correctly submit, load, unload and retrieve wafers from the implanter • M.S. can retrieve data from any given previous implant • M.S. can verify, load and write a recipe • M.S. knows correct procedures for shutting down the implanter (long and short term) • M.S. can explain the following NV20A functions (refer to figures 2A and 2B): A. NV20A source B. Extraction electrons and axes steering C. Quadrapole lens D. Resolving SLIT E. P.A electrode assembly F. Flag Faraday G. Electron shower	

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions | **Detailed Job Tasks** | **Knowledge Required**

- M.S. can explain the following PI9200 functions (refer to figures 1A and 1B):
  - A. Freeman source
  - B. Extraction electrode and extraction electrode alignment
  - C. Vanes
  - D. Shutter
  - E. Mass resolving system
  - F. P.A. electrode assembly
  - G. Flood gun
  - H. Charge monitor
  - I. Beam profiling

3. Viewing operation and equipment status
4. Continuous process logging
5. Viewing S.Q.C. data

APPENDIX D

Curriculum Advisory Committee and Validation Task List

SEMICONDUCTOR MANUFACTURING TECHNICIAN

CURRICULUM ADVISORY COMMITTEE

Description: Representatives of the companies requiring retraining of existing technicians and/or likely to hire new technicians who are graduates of the program; other experts qualified to contribute specialized knowledge; and representatives of the institutions likely to provide future training and retraining

Purpose: Provide technical assistance to CORD in curriculum design and development and assist CORD and TSTI in implementation of training/retraining program(s)

Meetings: Three between February 1990 and June 1991; in addition, substantial work will be done by mail

Responsibilities:

- Provide information relating to the technical aspects of technician jobs
- Assist in the design and data interpretation of needs assessment for training/retraining in member companies
- Review and comment on job descriptions and task analysis
- Validate technician job competencies
- Review curriculum/course models for training/retraining
- Evaluate laboratory requirements for training and retraining environment

SEMICONDUCTOR MANUFACTURING TECHNOLOGY EDUCATIONAL COORDINATING COMMITTEE

Dan Angel, President
District Administrative Offices
Austin Community College
P. O. Box 140526
Austin, TX 78714

Don Beck, Instructor
Electronics
Texas State Technical Institute-Harlingen
P. O. Box 2628
Harlingen, TX 78551-2628

Glen I. Bounds, Provost
Bill J. Priest Institute
for Economic Development
1402 Corinth
Dallas, TX 75215

Ron Brey, Director
Non-Traditional Instruction
District Administrative Offices
Austin Community College
P. O. Box 140526
Austin, TX 78714

Jim Burnett
Director of High Technology
Special Programs
Olney Central College
Olney, IL 62450

Ronald L. Carter, Ph.D., Director
NSD/CAEDS
University of Texas at Arlington
P. O. Box 19016
Arlington, TX 76019

Norman Colbath, Division Chair
Technology and Graphics
District Administrative Offices
Austin Community College
Austin, TX 78714

William H. Cox, Ph.D.
Dean of Instruction
Texas State Technical Institute-Waco
3801 Campus Drive
Waco, TX 76705

F. Pat Foy, Ph.D.
Manager, Technical Services
Business and Technology Center
Austin Community College
5930 Middle Fiskville Road
Austin, TX 78752

Don E. Goodwin, President
Texas State Technical Institute-Waco
3801 Campus Drive
Waco, TX 76705

Cecil L. Groves, Ph.D., Chancellor
Texas State Technical Institute-Waco
3801 Campus Drive
Waco, TX 76705

Kent Hansen, Chairman
Electronics Engineering
Linn-Benton Community College
6500 SW Pacific Boulevard
Albany, OR 97321

L. C. Harris, III, Director
Business Development
Business and Technology Center
Austin Community College
5930 Middle Fiskville Road
Austin, TX 78752

Jim Jackson, Director
Continuing Education
St. Michael's College
Winooski Park
Colchester, VT 05439

Don Johnson
Associate Vice President
Vocational Technical Education
Portland Community College
P. O. Box 19000
Portland, OR 97219

Rand Johnson, Director
Center for Business and
Economic Development
Salt Lake Community College
P. O. Box 30808
Salt Lake City, UT 84130

Vijay Joshi, Program Director
Microelectronics Technology
Durham Technical Community College
1637 Lawson Street
Durham, NC 27703

Bert Marcom, Assistant Vice President
of Academic Affairs
Austin Community College
P. O. Box 140526
Austin, TX 78714

George H. McShan, Dean of Instruction
Texas State Technical Institute-Harlingen
P. O. Box 2628
Harlingen, TX 78561-2628

Richard Moore, Associate Dean of
Instruction
Texas State Technical Institute-Waco
3801 Campus Drive
Waco, TX 76705

Wayne Parmley, Assistant Training
Specialist
Electronics Training Division
TEEX
The Texas A & M University System
College Station, TX 77843-8000

J. D. Pierson, Ph.D.
Associate Dean
Industrial Training & Economic
Development
Texas State Technical Institute-Waco
3801 Campus Drive
Waco, TX 76705

Lee Pulis, Department Chairman
High Technology Department
Indian Hills Community College
Airport Campus, Building 58
Ottumwa, IA 52501

John Schlosser, Division Director
Electronics & Manufacturing
Texas State Technical Institute-Harlingen
P. O. Box 2628
Harlingen, TX 78551-2628

Peter C. Scott, Director
Science Technology Division
Linn-Benton Community College
6500 SW Pacific Boulevard
Albany, OR 97321

Tsay-jiu Shieh, Assistant Professor
Electrical Engineering
University of Texas at Arlington
P. O. Box 19016
Arlington, TX 76019

George Van De Water, Director
School of Continuing Education
Salt Lake Community College
P.O.Box 20808
46000 South Redwood Road
Salt Lake City, UT 84130

Samuel S. Villareal
Associate Training Specialist
Electronic Engineering
TEEX
The Texas A & M University System
College Station, TX 77843-8000

James P. Wallace, Division Head
Electronics Training Division
TEEX
The Texas A & M University System
College Station, TX 77843-8000

Barbara Gutheil, Director
Continuing Education
Vermont Technical College
Randolph Center, VT 05061

Roger Perry, Provost
Champlain College
163 South Willard Street
P. O. Box 670
Burlington, VT 05402-0670

Jerome Beckmann
Hewlett Packard
815 14th Street
Loveland, CO 80537

CORD Staff
Daniel M. Hull, President and CEO
Walter Edling, Director of Programs
601 C Lake Air Drive
Waco, Texas 76710

DEVICE OR PROCESS - ______________________

Elements of Knowledge	Required Student Outcomes	Required Knowledge	Operator	Maintenance Technician	Process Technician	Manufacturing Technician

0 = Not Applicable
1 = Useful
2 = Important
3 = Essential

Technician Task List

PROCESS: PHOTOLITHOGRAPHY

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
I. Operations A. Checks status of parts (materials) inventory	· Reviews product type and counts	· Wafer characteristics · Wafer identification parameters, coding Wafer fl(?) Crystal orientation (1,1,)(1,0,0) Semiconductor equipment and materials Institute (SEMI) code Use of collimated light and x-ray diffraction inspection · Metallurgy of crystals Crystal structure Crystal growth Crystalline planes Solid solutions Impurities and doping				
	· Reviews material inventory and requirements	· Details of photolithography process				
B. Determines day's priorities	· Reviews manufacturing specifications	· Reading and interpretation of production specifications				
	· Reviews manufacturing schedules	· Reading and interpretation of production schedules				
	· Establishes work priorities and scheduling	· Basics of manufacturing scheduling · Basics of MRP				

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1?1

1?3

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
C Checks/adjusts equipment setting for desired operation	· Reviews manufacturing specifications · Adjusts, verifies all operating parameters	· Fundamentals of photochemistry · Fundamentals of inorganic and organic compounds Effect of time Effect of light wavelength Effect of temperature Polymerization Physics of light Frequency wavelength, energy Diffraction effects · Coating and film technology Surface preparation and adhesion Solvents used Film thickness measurement techniques Porosity Properties of liquids Viscosity units and measurements Density Specific gravity Pressure Flow measurement Flash point · Properties of gases Density Pressure Temperature Gas laws Particle pressures Flow measurement

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

0 = Not Applicable
1 = Useful

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
D. Prepares substrates as required by specifications	· Washes wafers using scrubbers, high pressure water · Spin dries · Desiccates · Dehydration bakes Low temperature bake High temperature bake Vacuum bake · Inspect for hydrophilic/hydrophobic condition	· Physics of rotation Angular speed, acceleration Centrifugal forces Balance · Physics of heat Temperature and its measurement Insulation, Thermal conducting Radiation, conversion, conduction Hydrophilic/hydrophobic conditions Constr(?????) of bakery ovens				
E. Vapor-primes substrates	· Loads, adjusts spin-coaters for priming Verifies liquid primer supply and specs · Verifies vapor primer supply and specs · Vacuum bakes primer	· Properties of primer liquids and gases Basic chemistry Physical properties Safety requirements Sources and handling · Operational details of primer application Methods Adjustments Quality checks				
F. Coat wafers with photoresist	· Loads, adjusts spin-coater for resist application · Verifies resist type and supply · Monitors specified process variables					

0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
G Soft bakes wafers	· Loads, adjusts bake process Convection ovens Vacuum ovens IR ovens Microwave ovens Conduction belt ovens	· Properties of photo resist materials Basic chemistry Physical properties Sensitizers Solvents Negative positive Oxygenation Additives Safety requirements Sources and handling · Operational details of application devices and baking processes Methods Adjustments Quality checks - Coverage - Thickness - Pinholes

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
H. Exposes wafers	· Loads, adjusts stepper · Verifies, loads proper masks and pellicles · Operates and monitors stepper · Monitors, adjusts exposure parameters Intensity Time Use of integrator	· Construction and operation of stepper Adjustments Routine maintenance Preventative maintenance Operating steps · Masking processes Single Double Multiple layers · Planarizing · Physics of ( ) sources Ultraviolet Electronic beam Diffraction Resolution Yellow light, spectral response · Dispense mechanisms Static Dynamic Moving Drawback				
I. Develops photoresist	Loads, adjusts developer process as required Immersion Spray Plasma	· Developer properties and chemistry · Developer processes Immersion Spray Plasma Puddle · Inspection and quality control parameters Under/over develop				

0 = Not Applicable

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
J Hard bakes wafers	· Loads, adjusts bake processes Vacuum Convection Infrared Radiation Microwave Hot plate	· Physics and construction of baking processes (See above)
K. Measures and inspects wafer per specs		· Familiarity with measurement devices and use Visual Microscopic Critical dimensions Edge distension,bridging,( ). edge quality Re???? lifting Scratches Contamination Pinholes · Familiarity with TPC Methods
L Transmit wafer to etch		

Operator
Maintenance Technician

0 = Not Applicable

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
II. Maintenance A. Calibrate and/or adjust photolithography equipment	· Adjust exhaust · Adjust spin speed · Adjust dispensing quantity · Adjust bake temperature and time · Adjust light intensity and distribution · Adjust alignment/spacing of stepper · Perform other stepper adjustments	· Mechanical knowledge Construction of photolithography equipment required calibrations Required adjustments Maintenance procedures - Routine - Preventative - Major · Knowledge of physics (Covered above) · Knowledge of chemistry (Covered above) · Knowledge of crystalline metallurgy (Covered above) · Knowledge of electricity/electronics Circuit analysis to board level Systematic trouble-shooting procedures Ability to read, interpret electrical specifications, circuit diagrams, and functional diagrams Ability to use state-of-the-art analysis equipment - VTVM - Osilloscope - digital · Knowledge of vacuum systems To level of trouble shooting components · Knowledge of pneumatic systems To level of trouble shooting components

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

0 = Not Applicable
1 = Useful

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
B Perform preventive (scheduled) maintenance	· Change lamp · Clean chuck · Lube transporter · Level stage · Adjust automatic wafer handler	· Knowledge of hydraulic systems To level of trouble shooting components · Knowledge of micro controllers To major component level				
C Troubleshoot and repair equipment	· Change, wipe down/flush wetbench filter · Change microcontroller · Change camera · Change/bake out sem gun tip · Restore vacuum to spin chuck · Correct misalignment in dispense arm · Repair stepper					
III Train others to do tasks in 1 and 2	· Lays out training materials and steps for others · Explains functions to others · Checks performance of others during training	· Able to organize and write out technical information Terminology Spelling Basic grammar, punctuation Perceptive writing Outlining Citations (references) · Able to communicate technical information verbally Prepare presentations Prepare support documents (diagrams, sketches, etc.) · Able to understand the basic teaching/learning process, and empathize with learners; Patience, tolerance Understands need for repetition, close supervision during learning				

0 = Not Applicable
1 = Useful

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
IV Multitasking and workload management	· Seeks ways to combine and coordinate tasks · Offers suggestions for operational improvement · Provides written and verbal reports · Presents reports and technical summaries verbally	· Experienced in working in teams or groups Willing to share information Willing to ask for help or ask questions Willing to accept advice Willing to compromise views Aware of creative thinking techniques				
V Improve cycle time and yield	· Performs trials (experiments) of different process steps and adjustments · Records and analyzes results in terms of yield and cycle time improvement · Tracks, records and analyzes basic defect patterns	· Knowledge of experimental methods · Able to record and organize data (Charts, graphs, etc.) · Able to interpret data and relate to hypotheses				
I Operations A Checks status of parts (materials) inventory	· Reviews product type and counts · Reviews material inventory and requirements					
B Determines day's priorities	· Reviews manufacturing specifications · Reviews manufacturing schedules · Establishes work priorities and scheduling	· Needs to know how to use inventory control system to look ahead and group lots of similar type to minimize number of set-ups · Checks equipment status for any repairs or adjustments on previous shift · Communicates with previous shift for passdown of information	2	1	3	3
C. Checks/adjusts equipment setting for desired operation	· Reviews manufacturing specifications · Adjusts, verifies all operating parameters	· Is certified and runs daily test on all equipment	3	1	3	3

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= Not Applicable

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
D. Prepares substrates as required by specifications	· Washes wafers using scrubbers, high pressure · Spin dries · Desiccates · Dehydration bakes Low temperature bake High temperature bake Vacuum bake	· Cleans used to promote adhesion or remove particulates collected in storage boxes, how to look for wafer spots left from incomplete dry. Why wafers must be raised above 100^{o} C to remove monolayers of water	1	1	3	3
	· Inspect for hydrophilic/hydrophobic condition	· Binocular Microscope angle measurement tech using drop water, meaning of hydrophobic and hydrophilic	1	1	3	3
E Vapor primes substrates	· Loads, adjust spin-coaters for priming · Verifies liquid primer supply and specs · Verifies vapor primer supply and specs · Vacuum bakes primer	· Reason for primer, hazards from material, oxygen contamination of vapor prime, need to exceed 100^{o} C, conductive vs radiant heat, change of wafer surface state to hydrophobic	2	2	3	3
F Coat wafers with photoresist	· Loads, adjusts spin-coater for resist application	· Types of resist application (static vs dynamic) different viscosities of resist, dyed resist filtering resist, hazards of chemical, importance of correct temp & humidity in room; how exhaust flow into cup can change resist thickness profile. Reason for Edge Bead removal, optical EBR, (Top & Bottom EBR techniques)	3	3	3	3
G. Soft bakes wafers	· Loads, adjusts bake process Convection ovens Vacuum ovens IR ovens Microwave ovens Conduction belt ovens	· Reason for softbake, what happens if temp is either too high or low. Types of softbake ovens	2	2	3	3

0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
H. Exposes wafers	· Loads, adjusts stepper · Verifies, loads proper masks and pellicles · Operates and monitors stepper · Monitors, adjusts exposure parameters Intensity Time Use of integrator	· How big a stepper field prints, different versions of reticles exist, particle size and pellicle stand off distance. Check stepper performance against "Mother" machine grid. How positive and negative resist react to light. Reasons for CP and Overlay variance. Global vs field by field alignment. How a stepper "MAP's a wafer	3	2	3	3
H1. Post exposure bake	· Loads adjust bake process	· Reduces standing waves · Stabilizes CO's · Increases adhesion	1	1	3	3
I. Develops photoresist	· Loads, adjusts developer process as required Immersion Spray Plasma	· Immersion used for small geometrics and long develop times. Spray for quick turnaround of wafers and automation. Plasma develop for exotic multilayer resist processes	1	1	3	3
J. Hard bakes wafers	· Loads, adjusts bake processes Vacuum Convection Infrared Radiation Microwave Hot plate	· Reason for hardbake & oven types, proximity baking on hotplates.	1	1	2	2

0 = Not Applicable

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
K. Measures and inspects wafer per specs	· Count defects	· Types of measurement tools (KLA, SEM, optical tools and intensity/reflectivity profiles				
K_1 Wafer inspection	· Measure critical dimensions					
L. Transmit wafer to etch	· Measure overlay	· Spore vs line profile				
		· Engineering spec vs production capability				
		· Entire CMOS, NMOS, Bipolar flow of wafers being processed to connect defect seen with correct process step	1	1	3	3
		· Is the defect at the current level or previous?	1	1	3	3
II. Maintenance	Adjust exhaust	· Use of strobe	2	3	3	3
A Calibrate and/or adjust photolithography equipment	· Adjust spin	· Volume & weight measurement				
	· Adjust dispensing quantity	· Different wavelengths of light in equipment	3	3	3	3
	· Adjust bake temperature and time	· What is a stepper "Baseline"; global vs field by field parameters; magnification, trapezoid; focus within a field can vary	3	3	3	3
	· Adjust light intensity and distribution		2	3	3	3
	· Adjust alignment/spacing of stepper		1	3	3	3
	· Perform other stepper adjustments	· How one stepper can be matched to a group	1	3	3	3
		· Lens vs stage parameters for overlay adjustment	1	3	2	3
B Perform preventive (scheduled) maintenance	· Changelamp	· How a lamps life is reduced when its shut off	1	3	3	3
	· Clean chuck	· Removal of finger prints from lamp	1	3	3	3
	· Lube transporter	· Lamp centering adjustments & uniformity	2	3	3	3
	· Level stage	· Diode adjustments for AWA sensing	1	3	2	3
	· Adjust automatic wafer handler					
C Troubleshoot and repair equipment	· Change, wipe down/flush wetbench filter	· Camera gain for various substitutes				
	· Change microcontroller	· Adjustments to SEM for focus adjustments				
	· Change camera	· Reasons for "COMETS at coat				
	· Change/bake out sem gun tip					
	· Restore vacuum to spin chuck					
	· Correct misalignment in dispense arm					
	· Repair stepper					
III. Train others to do tasks in 1 and 2	· Lays out training materials and steps for others	· Oral presentation skills	1	2	3	3
	· Explains functions to others					
	· Checks performance of others during training					

0 = Not Applicable
1 = Useful

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Technician Task List

PROCESS: PHOTOLITHOGRAPHY

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required
IV. Multi-tasking and workload management	· Seeks ways to combine and coordinate tasks	· Looks ahead for similar lots · Minimizes tool set-ups · Coordinates with co-workers
	· Offers suggestions for operational improvement	· Monitors SPC & tool operation and looks for trends
	· Provides written and verbal reports	· Shift to shift passdowns · Organization of lot & equipment status
	· Presents reports and technical summaries verbally	· Report writing, making charts & tables
V. Improve cycle time and yield	· Performs trials (experiments) of different process steps and adjustments	· Runs design of exp to find optimal equip parameters · Looks for tool to tool differences
	· Records and analyzes results in terms of yield and cycle time improvement	· Designs own job to be more efficient · Handles wafers as little as possible (minimal transfers)
	· Tracks, records and analyzes basic defect patterns	· SPC, Western Electric rules · What is "out of control · What are the common defects found in photolithography · What piece of equipment does a defect come from

Operator	Maintenance Technician	Process Technician	Manufacturing Technician
2	1	3	3
2	2	3	3
2	3	3	3
2	3	3	3
2	2	3	3
2	2	3	3
2	1	3	3
2	1	3	3
2	2	3	3

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0 = Not Applicable
1 = [illegible]

Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD

Basic Functions

I Operations
- A Verify status of product inventory
- B Tool status
- C Loading monitors
- D Loading software recipe and verifying recipes
- E Push run
- F Respond to alarms
- G Unload wafers
- H Measure stress, thickness
- I Visual inspection
- J SPC Input data to RSI
- K. Input data to COMETS Log lot out

Detailed Job Tasks

- a Log lot on COMETS
- a. Verify Number of WFRS, Process STEP, look for FCMs
- a. Look for KanBan TAG
- b. Verify up for Process
- b. All systems in SPEC
- c Pre measure WAFERS for stress
- c. Loan monitors into cassette according to SPEC
- c Flat orient WFRS on FLAT
- d Load recipe required in finder microspec
- d Check sequence and recipe
- d. Enter lot number and match sequence
- d. Place WFRS on machine
- f Verify problem
- f Unload WFRS if req'd
- h Measure thickness on prometrix
- h. Measure stress on FSM
- h. Measure Refractive INDEX ???????
- i. Look for particles in bright light
- i Look for deformities in film
- i Microscope inspection
- j Log into RSI
- j Run SPC program
- i Input data
- j Check for points out of control
- k. log lot out on comets:

Knowledge Required

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

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0 = Not Applicable

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Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD
(continued)

Basic Functions

II Maintenance
- A. Routine checks
  - 1 Particles
  - 2 Leaks
  - 3 Flow controller calibrations
  - 4 Facilities
  - 5 Pump operation
  - 6 Film Quality
- B Repair
  - 1 Chamber cleans
  - 2 Loadlock wipedowns
  - 3 Oring inspection/replace
  - 4 Robot calibrations
  - 5 Pressure calibration
  - 6 Flow controller zero
  - 7 Clean pump screens & forelines
  - 8 THIS LINE DID NOT COPY

Maintenance

Detailed Job Tasks

a1. Scan WFRS on tencor
a1. Run WFRS on machine
a1. Scan WFRS on tencor
a1. Verify particle counts are in SPEC
a2. Run lear rate routine
a2. Verify in SPEC
a2. Troubleshoot leak w/leak checker
a2. Verify baratron reading
a3. Run AFC calibration routine
a4. Read water flow, temperatura, exhaust flow gauges
a4. Adjust valves so gauges read in SPEC
a5. Check oil level
a5. Check pumping speed. Time To Pump chamber down - shut off ballast valve
a6. Run metal evaporator
a6. Run electrical test, place WFR on probe station, run program
b1. Vent chamber using routine
b1. Wear safety equipment
b1. Wipe chamber with (??????)
b1. Visual inspection of progress kit
b1. Pumpdown chamber
b1. Manually flow gauges & set pressure
b2. Same as b1
b3. Remove Orings
b8. Use DVM's, o'scopes & schematics to troubleshoot system
b4,b5,b6, follow routines
b) Shut off pumps & clean screens, & foreline

Knowledge Required

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

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0 = Not Applicable

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Technician Task List

PROCESS: CHEMICAL VAPOR DEPOSITION - CVD
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
III. Engineering	a. Prepare chemicals & monitors for stripping					
A SPC						
B Identify equipment operation/baselining equipment						
C Find causes for out of control processes						
D Training						
E. Prepare/present report						
IV Other						
A Stripping monitors						
B Ordering spare parts						

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: METALIZATION

Basic Functions

I Observe safety precautions
- A High voltage
- B RF
- C High vacuum

II Operations
- A Check gauges, controllers
- B Check gas flows, power, temperature
- C Verify status of product inventory
- D Load monitors
- E Monitor process and respond to alarms
- F Record process variables
- G Unload wafers
- H Measure film quality
- I Perform visual checks
- J Determine if process is within tolerance (spec)
- K Record date on product
- L Make process corrections
- M Follow flow chart

Detailed Job Tasks

- Awareness
- Volume, Pressure
- Read, adjust record values from meters, instruments
- Read, adjust record values from software or mechanical
- Review inventory, strategize process efficieness/workload; check supplies inventory
- Review, select, edit, recycle-handle cassettes, transfer wafers, insert cassette
- Check instrument valves, read & record
- Record KWH, cep time, argon N2, flows, temperatures, pressures, power
- Remove cassette, remove wafers, load into carrier
- Evaluate resistivity, performance, thickness, XRF & profilometry, alloy emiest mobile, or contamination, particles, stress
- Evaluate grand size, defects, specularity, color
- Plot value on control chart, review VS spec, evaluate control chart
- Record measurement results in database, start/end times
- Adjust by time, recipe parameters, minor adjust repair; convert new files
- Notify customer of incoming inventory, communicate process discrepancies

Knowledge Required

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

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0 = Not Applicable
1 = [illegible]

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions

III Maintenance
- A Power-up electronics
- B Reset controllers
- C. Regenerate pump-down curve (vacuum)
- D Evaluate RGA values or spectra
- E. Remove, clean, align, rebuild mechanical water holders
- F Vent vacuum chamber
- G Remove shields and targets
- H. Clean chambers and shields
- I Install clean shields and target
- J Remove, clean, inspect, replace, reinstall "o"-rings

Detailed Job Tasks

- Turn breakers on check visual over is on to controllers, reset reboot computer install floppy disks, initialize SKM; verify vacuum conditions
- Check temperature, status of pump, base pressure, value configuration/status, tumon
- Check temperature, clean poppett valve start compressors, check temperature, open valves/configuration
- Record pressure over time internal
- Select program, initialize ???, verify valves, calculate partial pressures, make decision
- Change cooling water ??? inventory clean shans, tools, record status and valves
- Adjust valves turn on N2 remove/screws/shields/target
- Vacuum and clean, inspect cleanliness
- Mix chemicals, install program, position shields, ??? clean program, evaluate resistivity of waters, dry shields, inspect shields inventory sharp
- Install shields/screws: Solvents, Cylinders, Flow Dynamics, DVM, MSe of gauges, instruments
- Inspect quality
- Place probes on target ???, take measurement, ???/report/???
- Remove shields, report K, re-install shields, report K

Knowledge Required

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: METALIZATION
(continued)

Basic Functions | **Detailed Job Tasks** | **Knowledge Required**

K Check target short-to-ground
L Troubleshoot short
M. Calibrate RF generation and 20 KW power supply
N. Check wafer handling, alignment, cleanliness
O Rebuild, replace, reinstall valves
P Troubleshoot electronic controlling boards
Q Trace electronic, plumbing, vacuum schematics, pneumatics
R Perform leak check
S Calibrate MFC (mass flow control)
T Keep maintenance log
U Calibrate heater controllers
V. Perform chemical cleans on deposited parts
W Charge and qualify gas bottles, lines
X Perform computer and system diagnostics
Y. Check microswitches, relays, sensors, IV's
Z Coordinate supplier support, spare parts
a Rebuild cathodes, recheck
b Align chamber
c. Check ground
d. Check water resistivity
e Calibrate pressure transducers
f Operate vacuum manually

IV Process technician functions
A System requalification
B Monitor CV plots
C. Monitor SPC controls and adjust
D. Measure resistivity

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

0 = Not Applicable

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Technician Task List

PROCESS: METALIZATION

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician

Basic Functions

E. Analyze film composition, step coverage groove(?) size, reflectivity
F Waste process operation specs
G. Adjust cathode magnets, and electric fields
H Measure and evaluate electro-migration
I Maintain relations with up- and down-stream process steps. Determine customer needs. (Understand requirements)
J Characterize, define process tolerances
K Design perform, analyze, conclude, report experiments
L Prepare, analyze equipment performance reports
M Implement SPC
N Generate troubleshooting guide
O. Reduce defect densities, increase yield

V Other Functions
A Train others
B Prepare, present reports
C Participate in team activities, problem solving
D Observe cleanroom practices
E Monitor utility usage and spare part use
F Participate in personal development activities

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0 = Not Applicable

Technician Task List

PROCESS: PLASMA ETCHING

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
I. Observe safety precautions A. High voltage B. RF C High vacuum	· Reviews product type and count · Reviews material inventory and requirements · Reviews prior shift pass downs · Ensures clean wafer boats					
II. Operations A. Checks status of parts (materials)						
B. Determines priorities	· Reviews manufacturing specifications · Reviews manufacturing schedules · Establishes work priorities and scheduling					
C Verifies etch system functionality	· Verifies chamber base pressure · Performs slow calibrations · Performs partial pressure test · Performs particle test · Performs etch rate test · Enter passive data from system test procedures into data base and determines if system performance specification has been met · Takes appropriate action based on the system test results Trouble shoots and corrects problems Notifies engineering ect...as indicated	· Basic plasma physics · Basic chemistry · Basic math				
D Etches send ahead wafers	· Optically inspect · Take appropriate action · Verifies process recipe					
E Observe and control system operation	· Monitor time to etch endpoint · Monitor shape of etch endpoint & curve · Respond to systems alarms					
F Inspect wafers at post etch	· Inspect wafers optically · Take appropriate action					

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0 = Not Applicable

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Technician Task List

PROCESS: PLASMA ETCHING
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
G Perform lot tracking	· Move lot on comets					
	· Enter appropriate data and comments					
H Moves lot (physically)	· Moves lot to next operation and location					
III. Maintenance	· Wipedown					
A Clean work station	· Vent etch chamber					
B Clean process chamber	· Remove chamber parts					
	· Clean chamber parts					
	· Install clean chamber parts					
	· Clean chamber					
	· Observe safety regs					
C Conditions etch chamber	· Loads wafers and runs conditioning and seasoning recipes					
D Responds to system failures	· Manipulate system using 'manual' commands					
	· Trouble shoots					
E Check cooling unit water level						

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: METROLOGY

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
I. Operations	Execute programs	Computer knowledge (General)				
A Optical film thickness measurements	Record data	Accurate transcription of results				
	Load/unload wafers	N/A				
	Enter data into Vax	Computer knowledge (General)	3	2	1	2
	Alignment of patterns	Microscope operation				
B Thin film resistivity Measurements	AS ABOVE	AS ABOVE	3	2	1	2
C Optical Critical Dimension Measurements	AS ABOVE	AS ABOVE	3	2	1	2
D Scanning Electron Microscope Critical Dimension Measurements	Execute programs	General computer knowledge				
	Record data	N/A	3	2	1	2
	Load/unload wafers	General computer knowledge				
	Enter data into Vax	SEM Theory & operation				
	Alignment of patterns					
	Operation of S.E.M.					
II Management of Activities, Priorities	Review manufacturing schedules, inventory	General computer knowledge				
	Make decisions on minute-to-minute, & hour-by-hour activities	Basic industrial engineering knowledge	3	3	3	3
III Maintenance						
A Perform scheduled maintenance						
B Trouble shoot & determine problem sources						
C. Repair problems						

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
I. Observe safety precautions A. High voltage B. Hazardous chemicals C. High pressure toxic gases D. Vacuum systems E. Elevated temperatures F. Facility evacuation procedures		· Electricity · Chemical safety · Gas handling and safety · Vacuum technology · Basic physics: heat · Industrial safety				
II. Operations A. Check status of furnace 1. Process gas supply	Monitor status of gas cabinet, upstream valves, pressure gauges, mass flow controllers, exhausts, burn-box	· Basic physics: Flow, pressure, temperature, combustion, heat, kinetic energy				
2. Temperature zones	· Monitor power delivered to zones and corresponding temperature offsets · Check autoprofile status	Basic physics: Temperature, heat conduction, convection, radiation, Joule Heating, Ohm's Law, thermoelectric effect				
3. Robot and elevator	· Verify status and coordinates	· Basic computer operation · Analytic geometry, Cartesian coordinates				
4. Upstream computer	· Monitor system status · Verify communications channels · Reboot computer system	· Basic computer operation · Ability to understand complex systems				
B. Checkstatus of metrology tools 1. Laser/light source	· Verify laser/light source operation	· Basic physics: Optics				
2. Focus/alignment	· Check system focus/alignment	· Basic physics. Optics · Geometry				
3. Control computer	· Reboot computer system Change hard disk cartridges	· Basic computer operation				
C. Check lot inventory 1. Kan-ban,JIT WIP	· Determine line status and status of inventory queues	· Elements of industrial engineering · Elements of production management · Basic economics				
2. Status in Process Control Computer (COMETS)	· Review lot status/history · Review factory communication messages	· Basic computer operation · Understanding of Electronic Mail and Word Processing				
D. Check test wafer inventory	· Refer to wet cleans tasks					
E. Check status of preclean tools						

0 = Not Applicable

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Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
F. Review process control charts	· Access SPC charts · Identify out-of-control conditions	· Statistical process control · Basic probability and statistics · Basic economics				
G Determine day's priorities H Adjust and/or test tools I Log in operation in Process Control Computer (COMETS)	· Operate machine · Perform subset of Basic PM's · Operate VAX terminal	· Machine operation · See under "Maintenance" · Basic computer operation · Understanding of process shop floor computer system				
J Perform preclean operation K Load material handler L Download process recipe from upstream computer (APEX)	· Refer to wet clean tasks · Operate machine · Operate Apollo workstation · Initiate data communication between APEX and furnaces	· Machine operation · Basic computer operation				
M Begin process run N Monitor run	· Operate machine · Operate machine	· Machine operation · Machine operation				
O Unload material handler P Perform Metrology operation Q Enter data and log out operation in COMETS	· Operate machine · Operate VAX terminal	· Machine operation · Basic computer operation				
R Move lots to proper position in fab facility III Process troubleshooting/process improvement A Design and perform experiments to isolate process problems	· Observe deviations from normal machine behavior · Design and run experiments · Document process problem remedies	· Process physics and chemistry · Electromechanical instrumentation · Experimental design				
B Design and perform experiments to improve process capability and/or operations efficiency	· Observe deficiencies in process or equipment · Observe deficiencies in operational procedures · Design and run experiments · Document improvements	· Process physics and chemistry · Experimental design				

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0 = Not Applicable

Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
IV Equipment maintenance						
A Preventive maintenance						
1 Quartzware change	· System rebuild	· Vacuum technology · Use of hand tools				
2 Quartzware clean/inspect	· Operate chemical quartz cleaners	· Basic chemistry				
3 Vac system disassembly and assembly	· System rebuild	· Vacuum technology · Use of hand tools				
4 Pump oil and filter change		· Vacuum technology				
5 Helium leak check	· Operate helium leak detector	· Vacuum technology				
6 Pyro torch assembly	· Rebuild pyro torch assembly	· Basic electronics · Gas handling · Basic electricity · Basic chemistry: combustion, Stoichiometry				
7 Termocouple adjustment	· Adjust position, connectors, reference circuits	· Electricity, physics: Thermoelectric effect · Properties of materials. metals and alloys				
8 Generate test recipes	· Apollo workstation operation	· Computer operation · Detailed understanding of process chemistry and physics				
9 Change PBr3, TMB, and TEOS Ampules	· Rebuild, refill, and test liquid source delivery systems	· Vacuum technology · Electricity · Gas handling				
10 Service burn box	· Clean and rebuild hydrogen burn box	· Gas handling · Electricity · Basic chemistry: combustion, Stoichiometry				
B System repair						
1 Vac system troubleshooting		Vacuum technology · Electronics (Power and Analog) · Mechanical systems				
2 Gas jungle troubleshooting		· Vacuum technology · Electronics · Fluid dynamics				
3 Microcontroller troubleshooting		· Electronics (Microprocessors)				
4 Upstream computer troubleshooting		· Computer operation · Electronics (Digital)				

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: OXIDATION/DIFFUSION/LPCVD

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
5. Furnace power electronics troubleshooting		· Heat transfer · Electronics (Power)				
6. Main system power distribution and UPS troubleshooting		· Electricity (Facility) · Electronics (Power)				
7. I/O module, alarm processor, gas module, and torch control troubleshooting		· Electronics (Analog and Digital)				
8. temperature module and temp control circuitry troubleshooting		· Heat transfer · Electronics (Power and Analog)				
9. Liquid source delivery system troubleshooting		· Fluid dynamics · Gas handling · Vacuum technology · Electronics				
10. Spare parts coordination						
11. Documentation of repair activities		· Electronic Mail and Word Processing				
V. Engineering support						
A. Organize, run, and evaluate experiments		· All of above				
B. Update and document process recipes		· All of above				
C. Update process and maintenance specs		· All of above				
D. Monitor and report on technical aspects of operation		· All of above				
VI. Training (Self and Others)						
A. Identify educational needs and take courses/ask questions						
B. Learn by doing: Experiment						
C. Teach what you know to your fellow workers						
VII. Meetings, reporting, and other group activities						

0 = Not Applicable
1 = Useful

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Technician Task List

PROCESS: WAFER CLEANING

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
I Operations A. Check status of parts (materials) inventory B Determines day's priority	· Reviews product type · Reviews materials inventory and requirements · Reviews specification · Reviews manufacturing schedules · Establishes work priority and scheduling	· Needs to know how to use inventory control to look ahead and group lots of similar type · Needs to know critical delay times between processes in order to prioritize processing · check equipment status for any repairs or adjustments communica. es with previous shift for passdown of information				
C Performs daily process checks on equipment for normal operation	· Reviews manufacturing specs · Performs daily particle and etch rate tests on appropriate process tanks · Performs bath bring-up operations as specified on process instructions	· Is certified to run operations · Able to use metrology equipments (particles counters, film thickness measurement equipments)				
D Chemical safety and handling	· Manually/automatically filling chemical tanks and cannisters	· Must possess full knowledge of chemical handling and safety · Safety gear must be worn at all times during chemical handling · Full knowledge of SEMATECH safety number and shower positioning				
E Operate pre-diffusion cleaning equipment	· Load/run cleaning equipment · Understand chemistry/recipe of operation · Understand "delay-time" between furnace/pre-clean operations · Understand chemical fill system to equipment · Able to troubleshoot (simple) any equipment problem · Full understanding of process flow (COMETS) system	· Be certified on equipment operation · Understand chemical safety and handling involved with equipment · Able to identify/correct · Process problems related to the chemistry involved				

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0 = Not Applicable
1 Useful

Technician Task List

PROCESS: WAFER CLEANING

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
II. Maintenance A. Calibrate and/or adjust wafer cleaning equipment	· Calibrate/adjust temperature controller Calibrate flow controllers · Calibrate motor speed controller · Adjust door seals/lids · Calibrate transducers Perform other wet bench/spray processor adjustments	· Use of strobe, volume and weight measurements				
B. Perform preventive maintenance	· Adjust robot arm · Filter changes · Change/replace plumbing components · Check for leaks · Check for mechanical wear · Check freon content of refrigeration unit					
C. Troubleshoot and repair equipment	· Change process controllers Calibrate/adjust flow controllers Check operation of plumbing components · Repair electrical components of equipment · Repair pneumatic/electrical pumps					
D. Training	· Layout training materials and steps for others · Explain functions to others					
F. Operate automatic photoresist stripping/wet etch equipment	· Load/run equipment · Understand chemistry/recipe of operation · Understand manual sink/automated sink operation Perform daily process checks (particles/etch rates) · Understanding of process flow system · Full awareness of chemical handling/safety · Solve simple operation/process problems associated with equipment component/robot	· Chemical safety · Knowledge of flow process control · Certification on piece of equipment				

0 = Not Applicable

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Technician Task List

PROCESS: IMPLANT

Basic Functions

I Operations
A. Wafer cross section
1 How a FET operates
2 Process flow
3 What the process does
4 Masking layers (oxides, nitrates)
5 Masking with photo resist
6 Implant damage
7 Channeling and twist angles and charging
8 Anneal and activation
B Safety
1 Acids and solvents
2 Gasses
3 High voltage
4 Radiation
5 Alarm system and evacuation routes
6 Maintaining Teflon boat integrity
C Wafer handling
1 Automatic flat finder
2 MGI wafer transfer
3 Vacuum pick-up techniques
4. Clean dirty boat or box
5 Clean work station
D Implant specific COMETS logging
1 Up/down protocol

Detailed Job Tasks

I. Safety
- M.S. has completed introductory safety class (given in orientation)
- M.S has completed radiation awareness class
- M.S. understands acid and solvent related safety issues (M.S. is able to recognize acid lines, safety cabinet, litmus paper, safety shower and shower rinse time, reactions of acids and solvents, and applications of implant specific acids and solvents.)
- M.S. understand implant specific gas related safety issues (M.S. is able to recognize implant specific hazardous gases and the dangers of each gas, and knows the location of the gas boxes on each machine.)
- M.S. understands high voltage related safety issues (M.S. is able to point out high voltage areas of each piece of equipment and present related safety precautions)
- M.S. understands radiation related safety issues (M.S. is able to point out "hot spots" on the equipment and can demonstrate radiation awareness)
- M.S. understands evacuation procedures (M.S. is able to follow evacuation routes from both of the implant service aisles as well as the implant bay. M.S. must also know how to read the Fab layout and follow evacuation routes for other bays)

II General Fab Procedure
- M.S. knows how to clean a dirty box or dirty boat

Knowledge Required

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

0 = Not Applicable
1 = Useful

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Technician Task List

PROCESS: IMPLANT

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
	· M.S. understands and practices the correct procedure for cleaning a work station					
	· M S. understands the importance of, and practices the following wafer handling techniques: 1. Uses the wafer lift, MGI Automatic Transfer, and MGI Automatic Flat Finder when handling boats of wafers. 2 Uses correct vacuum pick-up techniques 3. Does not lean over wafers 4 Does not cross over wafers with body parts 5 Uses correct boat handling techniques 6. Can correctly place wafers in a boat 7 Can correctly place a wafer in a single wafer carrier					
	III. Metrology Equipment					
	· M.S. can successfully load a desired program onto the Surfscan 5000					
	M.S. can operate Surfscan 5000 in manual or capture collection modes					
	M S knows the correct nomenclature for taking measurements on the RS 50/e and the Thermaprobe 3000					
	· M S can select and use correct files and programs for the RS 50/e and Thermaprobe 300					
	· M S knows control limits and frequency of measurement of the calibration wafers on the RS 50/e and Thermaprobe 300					
	M S can recall any data point in any RS 50/e					

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0 = Not Applicable

Technician Task List

PROCESS: IMPLANT
(continued)

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Basic Functions	Detailed Job Tasks	Knowledge Required
	or Therm aprobe 300 program · M.S. can recognize and delete false data points on the Thermaprobe 300 and RS 50/e · M S can bring up Thermaprobe 300 from a power off condition M S. can change Thermaprobe 300 light bulb · M S can recover a wafer from the Thermaprobe 300 · M S can back-up Thermaprobe system and data tapes IV. COMETS Logging · M S. can view the status of any entity in the implant bay · M.S. can view any given spec on COMETS M S. can correctly and accurately log any given event for an entity in the implant bay · M S. can view inventory of production and determine processing for each lot · M.S can perform continuous process logging · M S. knows the relationship between COMETS logging and E10-89 V R.T.A. · M.S can verify and edit the correct implant recipe · M.S. can verify and edit the RTS manual settings · M.S. knows the correct wafer flat orientation in the boat · M S. can correctly load and unload wafers · M.S knows what type of boat is to be used on the RTA	

Operator	Maintenance Technician	Process Technician	Manufacturing Technician

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0 = Not Applicable

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
	· M.S. knows why the dummy wafer is loaded in each cassette					
	· M.S. knows the correct annealing temperature for the implant anneal recipe					
	VI. Laser Scribe					
	· M.S. can perform long- and short-term shutdowns on the laser scribe					
	· M.S. can start the laser scribe from long- and short-term shutdown conditions					
	· M.S. can explain and perform scribing procedures on implant monitor wafers					
	· M.S. can correctly load and unload wafers from the RS 50/e, Surfscan 5000 and Thermaprobe 300					
	· M.S. can verify RS 50/e probe I.D., successfully change probe head, and perform probe conditioning					
	· M.S. has completed S.P.C. class					
	· M.S. can generate S.P.C. charts for the Prometrix Rs 50/e and the Thermaprobe 300					
	VII. Implant Process Flow					
	· M.S. knows implant process flow, including steps, species, resist strips and approximate poles					
	· M.S. knows usable particle monitor reject limits					
	· M.S. knows what to do with particle monitors exceeding usable particle monitor limits					
	· M.S. knows what type of wafers are to be used as particle monitors					
	· M.S. knows what to do with monitors for reclaim					

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0 = Not Applicable

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
	· M.S. knows what type of monitor is used for each implant test · M.S. knows the frequency and specifications for monitoring implant utility wafers · M S knows response protocol for out of control monitors	· Safety · IC manufacturing · SPC, · Data entry				

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
I. Operations A Implanter technical overview 1 Vacuum technology a Roughing pumps b Cryo pumps c Diffusion pumps d Turbo pumps e H C I G s, T C gauges, and other vacuum measurement devices 2 Introduction to the source chambers a Ionization and how radiation is created b ARC chamber functions c Source magnet d Extraction electrode e Beam steering and focusing f. Electron suppression 3 Introduction to the beamline/flight tube a. AMU and analyzer magnet b. Post accelerator electrodes c Beam focusing d Beam blow-up 4 Introduction to the process chamber a Faradays and suppression b Electron showers						

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0 = Not Applicable

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
	· M.S. knows the correct set-up sequence and procedures (refer to sections 5.0, 6.0 and 9.0 of spec IMPP0004) · M.S. knows how to correctly set-up and tune each implant (refer to sections 5.0, 6.0 and 9.0) · M.S. can correctly submit, load, unload and retrieve wafers from the implanter · M.S. can retrieve data from any given previous implant · M.S. can verify, load and write a recipe M.S. knows correct procedures for shutting down the implanter (long and short term) · M.S. can explain the following NV20A functions (refer to figures 2A and 2B): A. NV20A source B. Extraction electrons and axes steering C. Quadrapole lens D. Resolving SLIT E. P.A. electrode assembly F. Flag Faraday G. Electron shower · M.S. can explain the following PI9200 functions (refer to figures 1A and 1B): A. Freeman source B. Extraction electrode and extraction electrode alignment C. Vanes D. Shutter E. Mass resolving system F. P.A. electrode assembly G. Flood gun					

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: IMPLANT

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
	H. Charge monitor					
	I. Beam profiling					

0 = Not Applicable
1 = Useful
2 = Important
3 = [illegible]

Technician Task List

PROCESS: IMPLANT

(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
3 Viewing operation and equipment status						
4 Continuous process logging						
5 Viewing S Q C. data						
E Metrology equipment						
1 Thermawave Thermaprobe 300						
a Technical overview						
b. Operations						
c. Process flow						
2 Prometrix Omnimap R550/e						
a Technical overview						
b. Operations						
c Process flow						
3. Tencor surfscan 5000						
a. Technical overview						
b Operations						
c. Process flow						
F R T P 's						
1 Peak						
a. Technical overview						
b. Operations						
c. Process flow						
2. A G.						
a. Technical overview						
b. Operations						
c. Process flow						
G Laser scribe						
1. Technical overview						
2 Operations						
3 Process flow						
H Implant monitor flow						
1 Particle monitors						

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0 = Not Applicable
1 = Useful

Technician Task List

PROCESS: IMPLANT
(continued)

Basic Functions	Detailed Job Tasks	Knowledge Required	Operator	Maintenance Technician	Process Technician	Manufacturing Technician
2. Implant monitors 3 Corrective action response I Implant process flow 1 Phase 1 implants a Steps b. Species c Doses d. Resist strips						

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APPENDIX E

Industry Survey Responses—Summary

ATTACHMENT: Technician Training Questionnaire
(For SEMATECH Member Companies ONLY)

NAME: ____________________
COMPANY: ____________________

(1) What is your **company-wide** technician profile by job function (i.e., operator, process, device, equipment, test, facilities, integration, other)?

- define present status vs. future needs (with demographics).

(2) Provide an overview of your company's current technician training.

(3) What training resources/aides do you currently utilize?

(4) What type of career pathing is comprehended in the training profile?

(5) What is your company's **vision** for future technician training programs?

(6) What are the characteristics of a "world class" technician training program?

(7) What does your company want the educational institutions to do for you, both presently and in the future?

Industry Survey Responses

October 9-10, 1990

The concept of expanding operator training and capability to encompass other tasks is gaining support in the semiconductor manufacturing industry. Jobs such as quality control, routine maintenance, process adjustments and monitoring and efforts to enhance yields are increasingly added to the routine operator functions of product movement and machine operation.

These enhanced operator functions result in job titles such as manufacturing technician pr production technician. These changes do not eliminate the need for maintenance or specialized technicians, who have much more training in electronics and equipment repair skills and are capable of dealing with equipment and process problems beyond the capability of the manufacturing technician.

At the industry-wide training workshop held at SEMATECH on October 9 and 10, 1990, industry representatives submitted written responses to various survey questions regarding the evolving industry needs.

Following is a collection of responses quoted from the survey that relates to the evolving role of operators in relation to broader functions: (Underlining has been added to point out relevant items.)

Advanced Micro Devices

- Future implications: there will be a growing number of Manufacturing technicians with a broader skill base. Operators will be moving into technicians roles with added responsibility for minor maintenance and process engineering tasks.

- 5. What is your company's vision for future technician training?

  Our vision is that operators will be replaced by technicians which requires a broader skill base. To get there we will have to do extensive training utilizing both external and internal resources. In addition, team based groups will evolve with the responsibility of upgrading the skills of the team to match the requirements of the work.

- 6. What are the characteristics of a world class technician training program?

Sound basic knowledge and skills in Math, Chemistry, Physics and Communication including reading, writing, and speaking skills. A grounding in troubleshooting, SPC and statistics with a combination of vendor training, skill training on line, job rotation, and classroom training developed internally. In addition, specific skill training at the task level. There will be continuous cross training and training that expands ones education level. On average 4 hours per week spent in training.

IBM

- Future Needs

In the future we expect a higher percentage of production technicians and a reduction of production operators, with slight reductions in the other categories. This is being driven as we move toward making the production function self-sufficient for all day to day activities required to get product out the door. This also suggests higher education levels for this category. Since any new hires typically have a two year technical degree, all categories should also see improvements in educational level.

- Finally, as IBM focuses on improved efficiencies, jobs have been reorganized and employees have been given more responsibility which requires significant skill upgrade. One such group that has been affected are production employees. A total revamp of the jobs and career paths has taken place. The jobs have been redesigned to include not only production responsibilities but also the traditional support tasks such as quality, maintenance, engineering, safety and logistics.

- 5. What is your company's vision for future technician training programs?

Ideally, future technician needs will be sourced through the production function. Selection tests are being developed for production employees which not only test for basic education, but also for job related skills, such as attention to detail, decision making, and motivation. This improved selection, coupled with the skill based hierarchy will make this group ideal candidates to source other location technician needs.

Micron

- I. Technician profile by job function

  Technicians (Misc. Process)
  80% promoted from operator
  20% hired external sources

  Equipment Support Tech
  20% promoted from operator
  80% hired with tech degree

  Bench Tech
  10% promoted from operator
  90% hired with tech degree

  Engineering Technician (Process)
  80% promoted from ES and Bench Tech
  20% hired from external sources

- IV. Career Paths Available

  Operator---Set-up Tech---Assistant Tech---Technician---Engineering Tech---Engineer

  Operator---Process Tech---Process Engineer

  Operator---Bench Tech---Equipment Support Tech---Equipment Engineer

  Technician---Lead---Supervisor---Manager

- VI. World Class Technician Training Program

  Program which:

  1. Is designed to solve performance problems of current technicians
  2. Prepares current operators for advancement to technician
  3. Is business and customer driven
  4. Uses the most cost effective and efficient training methods
  5. Is evaluated by changes in work performance

- VII. Contributions of Educational Institutions

Currently:

1. Good working relationship
2. Eager to hear of industry needs, but often limited in resources and flexibility
3. Provide standard AA program for current employees
4. Provide applicants who meet hiring standards
5. Share curriculum information
6. Provide instruction for short-term specialized classes

Desired:

1. More offerings in semiconductor-specific courses
2. More flexibility in scheduling - meet shift needs
3. More depth in knowledge of instructors of semiconductor field
4. More short-term specialized classes brought on-line quickly
5. Vision in finding new ways to provide instruction

Harris

Process Engineering Technicians:	Levels
Process Engineering Technician	34
Sr. Process Engineering Technician	35
Process Engineering Specialist	36

The Process Engineering Technician job class family is predominantly comprised of employees that were promoted from the operator job class family based on their performance, job skills, and willingness to learn new skills with more responsibility. A two year degree is preferred but not required.

Quality Technicians:	Levels
Quality Technician	35
Sr. Quality Technician	36

The Quality Technician job family is comprised primarily of employees that were promoted from the operator job family based on their job performance and knowledge or hired in as a Technician because of experience and/or education (two year degree). Experienced operators can be promoted into the Quality Technician job family without a two year degree.

- Production Specialist

Production Specialist	Levels
Production Specialist	34
Sr. Production Specialist	35
Sr. Production Specialist (III)	36

The Production Specialist job family requires a two year degree in electronics or equivalent. Progression within this job family is based on job performance, years of experience, skill level, and ability to learn more complex tasks with varying degrees of increased responsibility. The job family is intended for employees that are multi functional in a broad range of manufacturing activities. Employees in this job family will be trained as an operator in manufacturing (i.e., align, etch, test, thin film, etc.) as well as in the technical areas such as Equipment Maintenance, Process Engineering, and support activities. This job will become predominate throughout manufacturing as we progress to self-directed work teams. The intent of this job family is to involve more employees in a wider range of activities with increased responsibility.

- For an example, at one plant location we are moving from the Operator job class (Wafer Processors, Testers, Assemblers, Quality Inspectors) to that of a Production Specialist. The Production Specialist category will represent employees that posses a two year degree, preform operational duties and some of the first echelon duties of the Equipment Maintenance, Process and Engineering Support technicians. The Production Specialist job function will represent employees that are multi-skilled, multi-faceted, and members of self directed work teams.

- 6. What are the characteristics of a "world-class" technician training program?

The characteristics of a "world-class" technician training program would provide the skill and knowledge to achieve total asset productivity. Technicians would operate, maintain (equipment maintenance), and utilize manufacturing tools and processes at a level for which they were designed at a zero failure rate. Training would address the technical, academic, administrative, team building, and operational skills needed to provide a well rounded program.

The CORD/SEMATECH project addresses the evolving role of the enhanced operator and does not necessarily cover the more equipment-orientated technicians.

APPENDIX F

Boise State University
Transformations
Course Descriptions

TRANSFORMATIONS at BOISE STATE UNIVERSITY

Sponsor US Department of Education through SEMITECH

Training provider Boise State University, Boise, Idaho

Participants 19 workers employed by MICRON--a semiconductor manufacturer

Attended training 3 hours per day, 4 days a week, 26 weeks

Received form MICRON 1.5 hours paid release time 4 days a week to attend training

Contributed 1.5 hours of personal time 4 days a week for class attendance plus study time

Worked 12 hour shifts--3 days "on", 3 "off"

Most worked overtime, several were "on-call"

Curriculum Adaptation of *Transformations* model--300 contact hours

- Applied Mathematics
- Principles of Technology
- Graphics for Technicians
- Mechanical Devices and Systems
- Fluid Power
- Keyboard skills
- Introduction to WordPerfect
- Communications
- Introduction to Chemistry

Transformations Course Descriptions

Pre Tech Curriculum

Pre Tech provides refresher courses in math and communication, introduces students to the use of personal computers, gives the students a basic understanding of drawings commonly used by technicians, provides fundamental knowledge and skills used in working with mechanical devices, and gives students the type of background in physics needed by workers who operate, maintain and repair equipment that incorporates interactive systems. Pre Tech helps orient students to the learning environment while providing basic skills they will use throughout the remaining curriculum and in future technical employment.

- **Applied Mathematics** makes math subjects relevant by showing how computation and analytic skills are used in the workplace, and by teaching problem-solving through hands-on, activity-centered environments. Topics include "Using Ratios and Proportions," "Working with Statistics," "Working with Scale Drawings," using a calculator and other subjects encountered in business/industrial workplace settings.
- **Applied Communication** helps students improve their reading, writing, listening, speaking, problem-solving, visual, and nonverbal skills, and transfer these skills to both their occupational and personal lives.
- **Use of Personal Computers** introduces the student to computer terminology and use of "canned" software such as word processing and spreadsheet programs.
- The **Technical Graphics** course teaches students how to develop and interpret technical sketches, and covers the use of line-types, multiview drawings, dimensioning and tolerance practices. The course also includes an introduction to computer-aided drafting and shows how computers are used to help make drawings of mechanical parts, buildings, and electronic circuits.
- Subjects presented in **Mechanical Devices and Systems** include different types of drive mechanisms such as belts, chains and gears. The course also teaches about actuators such as mechanical linkages and cam systems. Hands-on labs show: techniques for calculating chain and belt length; measurement and adjustment of backlash between gear teeth; installation procedures for seals and bearings; practices for working with aerobic and anaerobic sealants; and the use of precision measuring equipment such as a dial caliper and a dial indicator.
- **Principles of Technology 1** (PT) shows how physics concepts are used in mechanical, electrical, fluid and thermal systems—systems commonly encountered in contemporary technical employment. The physics concepts include *Force, Work, Rate, Resistance, Energy, and Power*. Each concept is reinforced through the use of hands-on learning, videotapes, math labs and hardware labs.

Tech Core Curriculum

The Tech Core helps students develop a basic understanding of scientific principles underlying technology. The Tech Core provides students the opportunity to develop fundamental skills in the areas of electricity/
electronics, fluid power, and quality control/statistical process control. The knowledge and skills developed in the Tech Core are commonly used in a variety of technical occupations.

- **Principles of Technology 2**, a continuation of PT 1, also shows how physics concepts are used in mechanical electrical, fluid and thermal systems. The physics concepts studied here include *Force Transformers, Waves and Vibrations, Energy Convertors*, and *Transducers*—concepts commonly encountered in technical equipment. Again, each concept is reinforced through the use of hands-on learning, videotapes, math labs and hardware labs.

- **Fluid Power Systems** covers common hydraulic and pneumatic systems and common types of pumps, control valves, pressure-control devices, flow regulators, cylinders and motors. Discussion of hoses, tubings and fittings is also presented. Hands-on labs emphasize the use of test devices such as a pressure gauge and a flowmeter to diagnose system faults.

- The **Electricity/Electronics** course is focused on voltage, current, resistance, Ohm's law, series and parallel circuits, capacitance, inductance, and the basic operation of solid-state devices. Hands-on labs include instruction in test equipment such as volt-ohm-milliammeters, oscilloscopes, and signal generators. AC and DC circuits are assembled and tested.

- **Quality Control** is an inspection methods course. Hands-on labs give practice in using all of the commonly used inspection instruments. Within the course, tolerance limits and tolerance systems are related to the inspection methods.

Tech Specialty Curriculum

Tech Specialty provides students the opportunity to develop specialized employment skills by taking selected course work in a specific area of technology. Tech Specialty is a flexible component of the retraining curriculum that can be modified to address job-specific training or general employment opportunities in the Saginaw region. The following describes examples of Tech Specialty training areas.

- **CNC** is focused on the fundamentals of Computer Numerical Control operations and terminology. Common program formats are presented. In hands-on labs, CNC machines are set up and operated.

- **QA/QC** provides instruction on quality control inspection methods and the relationship of quality control to production, inspection and engineering. Instruction includes discussion of frequency distribution, sampling, average and standard deviation. Quality control techniques are demonstrated and practiced in hands-on labs. Computer data are presented and problems focused on quality control statistical analysis are solved. The organization of quality control departments, the role of the technician in quality control and the implementation of basic quality control methods are discussed.

- **Plastic Injection Molding Technology** Tech Specialty curriculum gives students a combination of classroom and hands-on experience in the setup and operation of plastics injection molding equipment. Students learn about the characteristics of various types of thermoplastic materials including polystyrene, polyethylene, nylon, acrylic and Teflon. The students also learn about the structure of thermoplastic materials and the effect of structure on polymerization. Through hands-on lab work, the students gain knowledge and skills in the setup, operation, and fault correction of plastic injection molding equipment.

- **Electronic Systems** is a Tech Specialty curriculum that prepares workers for entry-level positions in electronics manufacturing environments and telecommunications. This curriculum builds on concepts learned in *Principles of Technology* and the Tech Core course, *Introduction to Electricity/Electronics*. The Electronic Systems curriculum places emphasis on the installation, operation, and use of electrical and electronic apparatus common to industrial and commercial applications. Students in the curriculum learn about technical concepts involving solid-state devices, rotating machinery, and programmable logic controllers. They also gain knowledge and skills in working with integrated circuits.

- The **Metal Blanking** Tech Specialty curriculum for the large sheet-metal-panel industry gives students technical knowledge and skills commonly used in sheet-metal forming operations. Students learn about some of the classifications of sheet metal, physical properties of sheet metal—hardness, toughness, ductility—and chemical properties of metal. Students learn about the construction and terminology associated with stamping dies and stamping operations. Through hands-on lab work, the students gain knowledge and skills in the setup and operation of metal blanking equipment.

APPENDIX G

Boise State University
Transformations
Demographics and Schedule

Class Demographic

Gender

Male	Female
17	2

Age

<18	18-22	23-29	30-39	40+
	3	5	4	4

Race

White	Black	Hispanic	Asian	Other
16		1	2	

Educational Attainment

<12th grade	12 yrs.	13-15 yrs.	16 years or more
	11	3	1

Educational or Vocational Goal

Job Placement	Job Promotion	Vocational Certification
	8	

High School Diploma or GED	College Credit
	1

AAS degree	BS degree
8	1

"TECH PREP"

SCHEDULE
2/22/91

DAYS:	MONDAY THROUGH THURSDAY
TIME:	5:00 PM TO 8:30 PM
TOTAL WEEKS:	22
TOTAL HOURS:	301.5
BEGINNING DATE:	MARCH 4, 1991
ENDING DATE:	AUGUST 5, 1991

COURSES:

APPLIED MATH
TOTAL HOURS: 42 (60)
TOTAL CLASSES: 12
DAYS: M/Th
TIME: 5-8:30pm
DATES: 3/4 TO 4/11
INSTRUCTOR: FRED BAKER
ROOM #: MT109

GRAPHICS
TOTAL HOURS: 31.5 (40)
TOTAL CLASSES: 9
DAYS: T
TIME: 5-8:30PM
DATES: 3/5 TO 4/30
INSTRUCTOR: REED SHINN
ROOM #: MT109

PERSONAL COMPUTERS
(10 HRS. KEYBOARDING, 10 HRS. INTRO TO MICROCOMPUTERS, 10 HRS. WORD PERFECT)
TOTAL HOURS: 30 (40)
TOTAL CLASSES: 15
DAYS: W
DATES: 3/6 TO 5/1
DAYS: M/W
DATES: 5/6 TO 5/22
TIME: 5-7PM
INSTRUCTOR: SUSAN JOHNSON & JEANINE BRINKERHOFF
ROOM #: TE 219

APPLIED COMMUNICATIONS
TOTAL HOURS: 19.5 (20)
TOTAL CLASSES: 13
DAYS: W
DATES: 3/6 TO 5/1
DAYS: M/W
DATES: 5/6 TO 5/15
TIME: 7-8:30PM
INSTRUCTOR: DARRO ANN PRESTRIDGE
ROOM #: MT109

MECHANICAL DEVICES
TOTAL HOURS: 21 (20)
TOTAL CLASSES: 6
DAYS: M/TH
TIME: 5-8:30PM
DATES: 4/15 TO 5/2
INSTRUCTOR: BOB ALLEN
ROOM #: V119

FUNDAMENTALS OF FLUID POWER
TOTAL HOURS: 28 (30)
TOTAL CLASSES: 8
DAYS: T/TH
TIME: 5-8:30PM
DATES: 5/7 TO 5/30
INSTRUCTOR: BOB ALLEN
ROOM #: V119

PRINCIPLES OF TECHNOLOGY I
TOTAL HOURS: 49 (60)
TOTAL CLASSES: 14
DAYS: M/W/TH
TIME: 5-8:30PM
DATES: 5/29 TO 7/1
INSTRUCTOR: ED LONSDALE
ROOM #: TB105 & TB107

CHEMISTRY
TOTAL HOURS: 31.5
TOTAL CLASSES: 9
DAYS: T
TIME: 5-8:30PM
DATES: 6/4 TO 7/30
INSTRUCTOR: MARK PURDY
ROOM #: TB105

PRINCIPLES OF TECHNOLOGY II
TOTAL HOURS: 49 (60)
TOTAL CLASSES: 14
DAYS: M/W/TH
TIME: 5-8:30PM
DATES: 7/3 TO 8/5
INSTRUCTOR: ED LONSDALE
ROOM #: TB105 & TB107

APPENDIX H

The Texas State Technical College at Waco Semiconductor Manufacturing Technology Outlines (9) Specialty Course

COURSE SYLLABUS

TITLE: SEMICONDUCTOR PROCESS I

NUMBER: SMT103

LECTURE: 3 LABORATORY: 4 CREDIT: 4

PREREQUISITE: NONE

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 Oct 91

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY:	DATE:

I. COURSE DESCRIPTION: (catalog description)

An introduction to Semiconductor Manufacturing Processes for the integrated circuit industry. This course will provide the basic understanding of materials, processes and equipment used in a wafer Fabrication facility. Emphasis will be the total process in lecture where the laboratory will undertake the safety, handling, and basic process in step by step activities to produce a Solar Cell. This course will only process with limited hazardous materials required.

II. COURSE OBJECTIVES:

This course is intended to introduce the student to the various process used in the fabrication of semconductor wafers. The student will be taught the characteristics of the materials, processes and equipment used in the fabrication, laboratory safety, material handling, chemical handling, and step by step process for production of Solar Cells.

Upon completion of this course, the student will be expected to demonstrate competency in these areas:

A) Define terms applicable to Semiconductor Manufacture with a working vocabulary of equipment, process, and procedure.

B) Demonstrate an understanding of the materials used in the manufacture of semiconductor devices.

C) Demonstrate an understanding of the applications and limitations of the materials used in semiconductor manufacture.

D) Demonstrate an understanding of the processes used, and the limitations of the processes used in the manufacture of various semiconductor devices.

E) Demonstrate an understanding of the types, functions, and operation of the equipment used in the manufacture of semiconductor devices.

F) Demonstrate an understanding of the processes used to make solar cells in a laboratory setting.

III. COURSE OUTLINE: (content)

A. Lecture

1) HISTORY OF THE SEMICONDUCTOR INDUSTRY

A) Birth of the industry

B) Solid State Devices

C) Stages of Manufacturing

D) Semiconductor Industry Growth

2) SEMICONDUCTOR MATERIALS AND PROCESS CHEMICALS

A) Atomic Structure (Bohr Atom Model)

B) Semiconductor Production Materials

C) States and Properties of Matter

3) LABORATORY AND CHEMICAL SAFETY

A) Chemical Safety with Acid

B) Chemical Safety with Solvents

C) Laboratory Safety Guidelines

D) Chemical Mix Safety Procedure

4) CONTAMINATION CONTROL

A) Contamination: The Problem

B) Contamination Sources

C) Contamination Control Strategies

5) WAFER FABRICATION

A) Goals of Wafer Farication

B) Wafer Terminology

C) Construction of Semiconductor Circuit

D) Packaging

E) Wafer Fabrication Yeild Limiters

6) OXIDATION

A) Silicon Dioxide Layer Uses

B) Thermal Oxidation Methods

C) Hi Pressure Oxidation Methods

D) Nitirdation

7) PHOTOLITHOGRAPHY

A) Overview of Photomasking

B) Ten Step Process

C) Photo Resist Positive and Negative

D) Photomasking Processes

E) Develop

F) Hard Bake

G) Inspect

H) Etching

8) DOPING

A) Forming a Junction

B) Diffusion

C) Ion Implantation

D) Atomic Considerations

9) DEPOSISTION

A) Chemical Vapor Deposition

B) Low Pressure Deposition

C) Deposited Films

10) METALIZATION

A) Metal Film Uses

B) Materials

C) Methods

11) MANUFACTURING TECHNOLOGY

A) Costs

B) Yields

C) Statistical Process Control

B. Laboratory

Lab will cover the required processes and techniques for the manufacture of Solar Cells in the Lab environment.

IV. REQUIRED TEXT OR MANUALS:

Microchip Fabrication by Peter Van Zant

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: QUALITY CONTROL / STATISTICAL PROCESS CONTROL

NUMBER: SMT104

LECTURE: 2 LABORATORY: 0 CREDIT: 2

PREREQUISITE: NONE

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 Oct 91

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY:	DATE:
____________________	____________________
____________________	____________________
____________________	____________________

I. COURSE DESCRIPTION: (catalog description)

A comprehensive study of the practical application of statistically sound methods to monitor (and continually improve) individual manufacturing processes and equipment performance.

II. COURSE OBJECTIVES:

This is an introductory to intermediate course in the practical application of statistics in a fabrication environment. This course is to cover introduction to the concepts, language and formulas in Statistical Quality Control and Statistical Process Control applications.

Upon completion of this course, the student will be able to:

1) Demonstrate a working vocabulary with terms applicable to statistical analysis.

2) Demonstrate a knowledge of the basic statistical formulas and inter-relationships.

3) Demonstrate sound data collection techniques, and design of statistical experiments.

4) Explain the importance of Quality testing and Quality improvement programs in the workplace.

5) Demonstrate their knowledge of the potential weak points of data collection techniques, data analysis techniques, and Praeto analysis techniques.

6) Demonstrate the ability to correctly operate and obtain accurat results from the computer software included in the book.

III. COURSE OUTLINE: (content)

A. Lecture

1) VARIABLES AND LEVELS OF MEASUREMENT

A) TYPES OF STATISTICAL MEASURES

B) LEVELS OF MEASUREMENT

C) TYPES OF VARIABLES

D) SUMMARIZING DATA

2) MEASURES OF CENTRAL TENDENCY

A) MODE

B) MEDIAN

C) MEAN

3) DISPLAY OF DATA

A) PIE CHARTS

B) BAR GRAPHS

C) BAR HISTOGRAMS

D) FREQUENCY POLYGONS

E) TYPES OF DISTRIBUTION CURVES

4) POPULATIONS AND SAMPLES

A) POPULATIONS

B) SAMPLES

5) MEASURES OF VARIABILITY

A) RANGE

B) AVERAGE DEVIATION

C) VARIENCE

D) DEGREES OF FREEDOM

6) NORMAL DISTRIBUTION

A) NORMAL CURVE

B) Z SCORE

7) PROBABILITY

8) DISTRIBUTION OF SAMPLE MEANS

A) ESTIMATING STANDARD ERROR OF THE MEAN

9) ESTABLISHING CONFIDENCE INTERVALS

A) 95% CONFIDENCE INTERVALS

B) 99% CONFIDENCE INTERVALS

C) t DISTRIBUTION

10) CORRELATION

A) COMPUTING THE CORRELATION COEFFICIENT

11) REGRESSION

A) REGRESSION OF Y ON X

B) REGRESSION OF X ON Y

C) MULTIPLE REGRESSION

12) TESTING FOR DIFFERENCE BETWEEN POPULATION MEANS

A) TESTING FOR DIFFERENCE BETWEEN INDEPENDENT MEANS VARIANCES ASSUMED EQUAL

B) TESTING FOR DIFFERENCE BETWEEN INDEPENDENT MEANS VARIANCES ASSUMED UNEQUAL

C) TESTING FOR DIFFERENCE BETWEEN DEPENDENT MEANS

13) ANALYSIS OF VARIANCE - ONE WAY

A) THE F DISTRIBUTION

B) TEST OF MULTIPLE COMPARISONS

C) TUKEY METHOD - EQUAL SIZED SAMPLES

D) SCHEFFE METHOD - UNEQUAL SIZED SAMPLES

14) ANALYSIS OF VARIANCE - TWO WAY

A) TWO - WAY ANALYSIS OF VARIANCE

B) ANALYSIS OF COVARIANCE

C) ONE-WAY ANALYSIS OF VARIANCE WITH REPEATED MEASURES

15) CHI-SQUARE TESTS

A) TEST FOR GOODNESS OF FIT

B) TEST FOR INDEPENDENCE OF TWO VARIABLES

C) TEST FOR EQUALITY OF PROPORTIONS

B. Laboratory
NONE

IV. REQUIRED TEXT OR MANUALS:
Introductory Statistics, a Microcomputer Approach
by Freeman F. Elzey

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

1 ea 5 1/4 floppy diskette, Double Sided/Double Density

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: SEMICONDUCTOR PROCESS II

NUMBER: SMT203

LECTURE: 3 LABORATORY: 6 CREDIT: 4

PREREQUISITE: SMT103, MATH 104, LET305

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 Oct 91

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY: DATE:

I. COURSE DESCRIPTION: (catalog description)

A continuation of SMT103 into the intermediate areas of Process. This course will provide an indepth look at wafer preparation, oxidation, diffusion, CVD, thin films, photolithography, methodologies, and etch methods. Students will be expected to produce working Solar Cells by the end of this course.

II. COURSE OBJECTIVES:

This course is designed for the student to apply the various process used in the fabrication of semconductor wafers. The student will be taught the characteristics of the materials, processes and equipment used in the fabrication, laboratory safety, material handling, chemical handling, and step by step process for production of Solar Cells.

Upon completion of this course, the student will be expected to demonstrate competency in these areas:

A) Define terms applicable to Semiconductor Manufacture with a working vocabulary of equipment, process, and procedure.

B) Demonstrate an understanding of the materials used in the manufacture of semiconductor devices.

C) Demonstrate an understanding of the applications and limitations of the materials used in semiconductor manufacture.

D) Demonstrate an understanding of the processes used, and the limitations of the processes used in the manufacture of various semiconductor devices.

E) Demonstrate an understanding of the types, functions, and operation of the equipment used in the manufacture of semiconductor devices.

F) Demonstrate an understanding of the processes used to make solar cells in a laboratory setting.

III. COURSE OUTLINE: (content)

A. Lecture

1) SOLAR CELL PRODUCTION PROCESS

A) Preparation of materials and equipment

B) Production of Solar Cells in the Lab

C) Standardized Testing of Solar Cells

D) Documentation of Solar Cell Quality

2) SEMICONDUCTOR MATERIALS AND PROCESS CHEMICALS

A) Atomic Structure (Bohr Atom Model)

B) Semiconductor Production Materials

C) States and Properties of Matter

3) LABORATORY AND CHEMICAL SAFETY

A) Chemical Safety with Acid

B) Chemical Safety with Solvents

C) Laboratory Safety Guidelines

D) Chemical Mix Safety Procedure

4) CONTAMINATION CONTROL

A) Contamination: The Problem

B) Contamination Sources

C) Contamination Control Strategies

5) WAFER FABRICATION

A) Goals of Wafer Farication

B) Wafer Terminology

C) Construction of Semiconductor Circuit

D) Packaging

E) Wafer Fabrication Yeild Limiters

6) OXIDATION

A) Silicon Dioxide Layer Uses

B) Thermal Oxidation Methods

C) Hi Pressure Oxidation Methods

D) Nitirdation

7) PHOTOLITHOGRAPHY

A) Overview of Photomasking

B) Ten Step Process

C) Photo Resist Positive and Negative

D) Photomasking Processes

E) Develop

F) Hard Bake

G) Inspect

H) Etching

8) DOPING

A) Forming a Junction

B) Diffusion

C) Ion Implantation

D) Atomic Considerations

9) DEPOSISTION

A) Chemical Vapor Deposition

B) Low Pressure Deposition

C) Deposited Films

10) METALIZATION

A) Metal Film Uses

B) Materials

C) Methods

11) MANUFACTURING TECHNOLOGY

A) Costs

B) Yields

C) Statistical Process Control

B. Laboratory

Lab will cover the required processes and techniques for the manufacture of Solar Cells in the Lab environment, and tracking of the tested Cell quality.

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: MANUFACTURING METHODOLOGIES

NUMBER: SMT302

LECTURE: 3 LABORATORY: 4 CREDIT: 4

PREREQUISITE: NONE

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 Oct 1991

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY: DATE:

REVIEWED BY	DATE

I. COURSE DESCRIPTION: (catalog description)

This course will provide a basic understanding of inventory/production control logistics and resultant product cycle time and costs. There will be particular emphasis in understanding of individual productivity/efficiency as it relates to overall manufacturing success.

II. COURSE OBJECTIVES:

This course will challenge the student to understand the inter-relationships of the inventory, production, logistics, documentation, work flow, employee contributions, and efficiency to the profits or losses of a company.

Upon completion of this course, the student will be able to:

1) Demonstrate a working vocabulary with terms applicable to Manufacturing techniques.

2) Demonstrate a knowledge of the basics of manufacturing, and the inter-relationships of the planning, coordination, and organization activities inside the company.

3) Demonstrate sound inventory, production, logistics, documentation, work flow, and efficiency planning and control principles.

4) Explain the importance of Planning and Control programs in the manufacturing environment.

5) Demonstrate their knowledge of the potential weak points in the manufacturing environment, and methods to detect, improve, and prevent problems.

III. COURSE OUTLINE: (content)

A. Lecture

1) INVENTORY CONTROL

A) INVENTORY AS A PRODUCTION EXPENSE

B) JUST IN TIME INVENTORY PLANNING

C) INVENTORY IN WORK FLOW PLANS

D) INVENTORY DOCUMENTATION

E) AUDIT TRAILS IN THE STOCKROOM

2) MANUFACTURING LEAD TIME PLANNING

A) PRODUCTION LAYOUT, FLOWS, AND SCHEDULING

B) WORK FLOW PLANNING

C) MANUFACTURING CAPACITY PLANNING

D) MANUFACTURING WORKLOAD PLANNING

3) PRODUCTION CONTROL

A) QUALITY IMPACTS ON PROFITS/LOSSES

B) PRODUCTION YIELDS AND QUALITY ANALYSIS

C) PRODUCTION QUALITY TRACKING

D) PRAETO ANALYSIS FOR PROBLEM RESOLUTION

4) LABOR

A) LABOR AS A MAJOR EXPENSE

B) LABOR EFFICIENCY PROGRAMS

C) EMPLOYEE TRAINING COST VERSUS BENIFIT

D) EMPLOYEE CONTRIBUTION PROGRAMS

5) PRODUCT CYCLE TIME

A) EFFECTS ON PROFITS AND LOSSES

B) JUST IN TIME PRODUCTION PLANNING

C) PRODUCTION DOCUMENTATION

D) WORK IN PROCESS TRACKING

6) AUTOMATION IN MANUFACTURING

A) ROBOTIC APPLICATIONS

B, BAR CODE TRACKING SYSTEM INTEGRATION

C) AUTOMATED MATERIAL DELIVERY SYSTEMS

D) COMPUTER AIDED MANUFACTURING EQUIPMENT/TECHNOLOGY

7) COMPUTERIZATION IN MANUFACTURING

A) COMPUTER AIDED DESIGN EQUIPMENT/TECHNOLOGY

B) WORK IN PROGRESS TRACKING/ANALYSIS TECHNOLOGY

C) AUTOMATED QUALITY TRACKING/ANALYSIS TECHNOLOGY

D) AUTOMATED MATERIAL SCHEDULING SYSTEMS

E) AUTOMATED MATERIAL PURCHASING SYSTEMS

B. Laboratory

Lab will apply the Manufacturing Methodologies to the production of Solar Cells.

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: SEMICONDUCTOR PROCESS III

NUMBER: SMT303

LECTURE: 3 LABORATORY: 12 CREDIT: 6

PREREQUISITE: SMT203, MATH 124, LET317

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 Oct 1991

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY: DATE:

REVIEWED BY	DATE

I. COURSE DESCRIPTION: (catalog description)

A more advanced and detailed study of each process learned in previous Process and Fabrication courses. Emphasis will be on producing the highest yeild, highest efficiency Solar Cell possible. Students will engage in all areas of the manufacturing procedure.

II. COURSE OBJECTIVES:

This course is designed for the student to apply the various process used in the fabrication of semconductor wafers. The student will be taught the characteristics of the materials, processes and equipment used in the fabrication, laboratory safety, material handling, chemical handling, and process improvement techniques for production of Solar Cells.

Upon completion of this course, the student will be expected to demonstrate competency in these areas:

A) Define terms applicable to Semiconductor Manufacture with a working vocabulary of equipment, process, and procedure.

B) Demonstrate an understanding of the materials used in the manufacture of semiconductor devices and alternative materials for quality, yeild, and output improvement.

C) Demonstrate an understanding of the applications and limitations of the alternative materials used in semiconductor manufacture.

D) Demonstrate an understanding of the processes used, and the limitations of the processes used in the manufacture of various semiconductor devices and quality improvement techniques.

E) Demonstrate an understanding of the types, functions, and operation of the equipment used in the manufacture of semiconductor devices.

F) Demonstrate an understanding of the processes used to improve solar cells in a laboratory setting.

III. COURSE OUTLINE: (content)

A. Lecture

1) SOLAR CELL PRODUCTION PROCESS

A) Preparation of materials and equipment

B) Production of Solar Cells in the Lab

C) Standardized Testing of Solar Cells

D) Documentation of Solar Cell Quality

2) LABORATORY AND CHEMICAL SAFETY

A) Chemical Safety with Acid

B) Chemical Safety with Solvents

C) Laboratory Safety Guidelines

D) Chemical Mix Safety Procedure

3) CONTAMINATION CONTROL

A) Contamination: The Problem

B) Contamination Sources

C) Contamination Control Strategies

4) OXIDATION

A) Silicon Dioxide Layer as Concentrator

B) Thermal Oxidation Methods with Spin on Glass

C) Hi Pressure Oxidation Methods

D) Nitirdation

5) PHOTOLITHOGRAPHY

A) Alternative Methods of Photomasking

B) Ten Step Process Integration

C) Photo Resist Positive and Negative

D) Photomasking Processes

E) Develop Alternatives

F) Hard Bake

G) Inspect Techniques for Product Improvement

H) Etching Alternatives

8) DOPING

A) Forming a Junction

B) Diffusion

C) Ion Implantation

D) Atomic Considerations

9) DEPOSISTION

A) Chemical Vapor Deposition

B) Low Pressure Deposition

C) Deposited Films

10) METALIZATION

A) Metal Film Alternatives

B) Materials Alternatives

C) Methods

11) MANUFACTURING TECHNOLOGY

A) Costs

B) Yields

C) Statistical Process Control

B. Laboratory

Lab will cover the required processes and techniques for improvements in the manufacture of Solar Cells in the Lab environment, as well as tracking of the tested Cell quality.

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: CONTAMINATION CONTROL, ION IMPLANT

NUMBER: SMT304

LECTURE: 3 LABORATORY: 4 CREDIT: 4

PREREQUISITE: NONE

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 04 1991

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY:	DATE:

I. COURSE DESCRIPTION: (catalog description)

A detailed study of processes, materials, and equipment in the following wafer fabrication areas: basic clean-room concepts and design, defect density analysis and control, wafer handling techniques and processing procedures, ion implant systems and dose control, ion ranges, annealing and diffusion of dopant impurities, shallow junction effects, and gettering.

II. COURSE OBJECTIVES:

This is a more advanced study in the area of contamination control, and what can be done to limit the problems caused by contamination in the production of semiconductor devices.

Upon completion of this course, the student will be able to:

1) Converse with a working vocabulary with terms applicable to Contamination Control.

2) Demonstrate a working knowledge of Contamination Control Processes.

3) Demonstrate a working knowledge of Contamination Control Materials.

4) Demonstrate a working knowledge of Contamination Control Materials.

5) Demonstrate a working knowledge of Contamination Control Equipment.

6) Demonstrate a working knowledge of Contamination Control Clean Room Concepts.

7) Demonstrate a working knowledge of Contamination Control Clean Room Design.

8) Demonstrate a working knowledge of Contamination Control Defect Density Analysis.

9) Demonstrate a working knowledge of Contamination Control Wafer Handling Techniques.

10) Demonstrate a working knowledge of Contamination Control Dopant Impurities.

11) Demonstrate a working knowledge of Contamination Control Gettering.

III. COURSE OUTLINE: (content)

A. Lecture

1) Contamination Control Processes

A) Processes Used for Contamination Control

B) Class 1000 Considerations

C) Class 100 Considerations

D) Class 10 Considerations

2) Contamination Control Materials

A) Materials Used for Contamination Control

B) Class 1000 Considerations

C) Class 100 Considerations

D) Class 10 Considerations

3) Contamination Control Equipment

A) Equipment Used for Contamination Control

B) Class 1000 Considerations

C) Class 100 Considerations

D) Class 10 Considerations

4) Contamination Control Clean Room Concepts

A) Class 1000 Considerations

B) Class 100 Considerations

C) Class 10 Considerations

5) Contamination Control Clean Room Design

A) Class 1000 Considerations

B) Class 100 Considerations

C) Class 10 Considerations

6) Contamination Control Defect Density Analysis

A) Equipment Used for Defect Analysis

B) Analysis Techniques

C) Improvement Reporting

7) Contamination Control Wafer Handling Techniques

A) Class 1000 Considerations

B) Class 100 Considerations

C) Class 10 Considerations

8) Contamination Control Dopant Impurities

A) Dopant Purity Efforts

B) Wafer Purity Efforts

C) Counter Acting Impurities

D) Impurity Removal Techniques

9) Contamination Control Gettering

A) What is Gettering

B) Gettering Techniques

C) Gettering Limitations

D) Alternatives to Gettering

B. Laboratory

Lab will cover the planning and implementation of Contamination Control techniques in the production of Solar Cells.

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

VI. GRADING POLICY:

VII. ATTENDANCE POLICY:

COURSE SYLLABUS

TITLE: PREVENTATIVE MAINTENANCE

NUMBER: SMT306

LECTURE: 2 LABORATORY: 4 CREDIT: 3

PREREQUISITE: NONE

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE:

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY:	DATE:

I. COURSE DESCRIPTION: (catalog description)

A study of the basic techniques, benifits, and costs of a comprehensive equipment maintenance program, including the impact/improvement of manufacturing parameters such as mean-time-between-failures (MTBF), mean-time-to-repair (MTTR), machine availablity, and utilization.

II. COURSE OBJECTIVES:

This is an introductory course on the effects of an efficient equipment maintenance program in the production environment. The student will learn about the key elements of the preventative maintenance program, how to identify the elements required, and how to identify changes that need to be made to existing programs.

Upon completion of this course, the student will be able to:

1) Converse with a working vocabulary with terms applicable to Preventative Maintenance and repair maintenance.

2) Demonstrate a working knowledge of calculating Mean Time To Repair in a maintenance program.

3) Demonstrate an understanding of the use of Mean Time To Repair in a maintenance program.

4) Demonstrate a working knowledge of calculating Mean Time Between Failures in a maintenance program.

5) Demonstrate an understanding of the use of Mean Time Between Failures in a maintenance program.

6) Demonstrate a working knowledge of caculating Machine Availability in a maintenance program.

7) Demonstrate an understanding of the use of Machine Availability in a maintenance program.

III. COURSE OUTLINE: (content)

A. Lecture

1) PREVENTATIVE MAINTENANCE PROGRAMS

A) What is a Preventative Maintenance Program

B) What does a Preventative Maintenance Program Do

C) Who is responsible for Preventative Maintenance

D) How is a Preventative Maintenance Program Started

2) REPAIR MAINTENANCE PROGRAMS

A) What is a Repair Maintenance Program

B) What does a Repair Maintenance Program Do

C) Who is responsible for Repair Maintenance

D) How is a Repair Maintenance Program Started

3) MAINTENANCE TECHNIQUES

A) Board Swapping repair techniques

B) Component Level Repair Techniques

C) Service Contract Maintenance

D) In House Maintenance

4) PREVENTATIVE MAINTENANCE PROGRAM BENIFITS

A) Reduction of Equipment Down Time

B) Reduction of Repair Maintenance Costs

C) Production Process Accuracy

D) Product Quality

5) REPAIR MAINTENANCE PROGRAM BENEFITS

A) Reduced Equipment Down Time

B) Factory Contract Support

C) Reduction of Spare Parts Inventory Costs

D) Engineering Support

6) MAINTENANCE PROGRAM COSTS

A) Preventative Maintenance Requirements

B) Supplies Inventory Requirements

C) Repair Maintenance Requirements

D) Repair Inventory Requrements

7) MEAN TIME TO REPAIR

A) What is MTTR

B) How is MTTR Used

C) Calculating MTTR

D) Evaluating MTTR Results

8) MEAN TIME BETWEEN FAILURES

A) What is MTBF

B) How is MTBF used

C) Calculating MTBF

D) Evaluating MTBF Results

9) MACHINE AVAILABILITY

A) What is AVAILABILITY

B) How is AVAILABILITY used

C) Calculating AVAILABILITY

D) Evaluating AVAILABILITY Results

B. Laboratory

The Lab will cover the installation and execution of a Preventative Maintenance Program on existing equipment

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: SEMICONDUCTOR MANUFACTURING PROJECTS

NUMBER: SMT312

LECTURE: 1 LABORATORY: 8 CREDIT: 3

PREREQUISITE: SMT103, SMT203, SMT303, EEC1004, EEC1104, LET108

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 12-04-1991

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY: DATE:

I. COURSE DESCRIPTION: (catalog description)

A laboratory intensive exercise to allow the student to apply integrated process and equipment knowledge to fully fabricate a working circuit on silicon or improvement in equipment or process. This project will require execution, analysis, and documentation of all relavant aspects of the manufacturing sequence, including final electrical test results.

II. COURSE OBJECTIVES:

This is an advanced course designed to challenge the student to go beyond the routine of following prescribed process steps. The student is challenged to utilize all of the knowledge from all of the previous courses in the program.

Upon completion of this course, the student will be able to:

1) Demonstrate a working knowledge and understanding of the process steps required to produce a semiconductor device.

2) Demonstrate a working knowledge of the inter-relationships of the sequence of processes used in the production of semiconductor devices.

3) Demonstrate a working knowledge of the equipment used in the processing of the semiconductor device.

4) Demonstrate a working knowledge of the maintenance, repair, and improvement of the equipment used to produce semiconductor devices.

5) Demonstrate an understanding of the steps to evaluate, analyze, and improve on the processing of silicon devices.

6) Demonstrate an understanding of the steps to evaluate, analyze, and improve on the equipment used to process the silicon devices.

III. COURSE OUTLINE: (content)

A. Lecture

Lecture is limited to counselling and individual assistance on assigned projects.

B. Laboratory

Lab time is allowed for the development, completion, and documentation of assigned project.

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

COURSE SYLLABUS

TITLE: DIAGNOSTICS AND TROUBLESHOOTING OF AUTOMATED SYSTEMS

NUMBER: SMT314

LECTURE: 2 LABORATORY: 4 CREDIT: 3

PREREQUISITE: NONE

PREPARED BY: ROBERT STONE

APPROVED BY:

DATE: 22 Oct 1991

THIS SYLLABUS HAS BEEN REVIEWED AND IS CURRENT ON THE DATE INDICATED

REVIEWED BY: DATE:

I. COURSE DESCRIPTION: (catalog description)

A structured approach to the diagnosis and problem-solving methods of semiconductor processes and equipment to increase the operational stability and availability. The primary focus of the instruction is to emphasise the automated aspects of the equipment.

II. COURSE OBJECTIVES:

This is an introductory course to the applications, use, implementation, improvement, and repair of automated equipment in the manufacture of semiconductor devices. Particular attention will be paid to practical function in the Solar Cell fabrication Lab.

Upon completion of this course, the student will be able to:

1) Converse with a working vocabulary with terms applicable to automated equipment and repair technology.

2) Demonstrate an understanding of the needs and requirements of automated systems in the manufacture of semiconductor devices with emphasis on Solar Cell Production.

3) Demonstrate an understanding of the purpose and reasons for the use of automated and semi-automated systems in the Clean Room Environment.

4) Demonstrate an understanding of the needs survey of requirements for the design and implementation of automated systems for the fabrication operations.

5) Demonstrate an understanding of the design, construction, and implementation of automated systems for the fabrication activity.

III. COURSE OUTLINE: (content)

A. Lecture

1) THE HISTORY OF AUTOMATED SYSTEM APPLICATIONS

A) The development of Automated Systems

B) The Industry Requirements for Automated Systems

C) Automated Systems Impact on Industry

D) Automated Systems as an Industry

2) AUTOMATED SYSTEMS IN SEMICONDUCTOR FABRICATION

A) Automation versus Manual Processing

B) Types of Automation in Industry

C) Levels of Automation

D) Cost versus Benifits of Automation

3) TERMINOLOGY OF AUTOMATED SYSTEMS

A) Terms at Component Level

B) Terms at Module or Subassembly Level

C) Terms at System Level

D) Terms at Cluster System Level

4) AUTOMATED SYSTEMS APPLICATIONS IN RESEARCH

A) Need or Requirement for Automation

B) Benifits vs Cost Analysis

C) Development of Present Automation Systems

D) Development of Future Automation Systems.

5) AUTOMATED SYSTEMS IN PRODUCTION ENVIRONMENTS

A) Need or Requirment for Automation

B) Benifits vs Cost Analysis

C) Development of Present Automation Systems

D) Development of Future Automation Systems

6) AUTOMATED SYSTEM REQUIREMENTS SURVEY

A) Present Production Techniques and Problems

B) Job Criteria for Automation

C) Complexity vs Feasability of Automation

D) Benifits vs Cost of Automation

7) PURPOSE OF AUTOMATED SYSTEMS

A) Reduction of Personnel Requirements

B) Reduction of Repetitive Jobs

C) Accuracy of Automation Systems

D) Repeatability of Automated Systems

E) Hazardous Environment Automation

8) DESIGN OF AUTOMATED SYSTEMS

A) Mechanical Limitations

B) Complexity Limitations

C) Computer Applications

D) Maintenance Considerations

9) CONSTRUCTION OF AUTOMATED SYSTEMS

A) Technology Availibility at Present

B) Development of New Technology

C) Cost of Production of Automated Systems

D) New Applications of Existing Automation

10) IMPLEMENTATION OF AUTOMATED SYSTEMS

A) Upgradable System Applications

B) Reliability Considerations for Automation

C) Maintainability Considerations for Automation

D) Integration Considerations for Automation

B. Laboratory

The Lab will look at automation applications and potential in the existing facility. Each functional part of the process will be surveyed, and projects will be undertaken.

IV. REQUIRED TEXT OR MANUALS:

V. REQUIRED STUDENT MATERIALS AND SUPPLIES:

1 ea Spiral Notebook 70 pages minimum

2 ea #2 Pencils

2 ea Black Fine Ballpoint Pens

1 ea Metal Metric/English Scale or Ruler 6 inches long

VI. GRADING POLICY:

A = 90 - 100

B = 80 - 89

C = 70 - 79

D = 65 - 69

VII. ATTENDANCE POLICY:

Students must comply with school catalog policy.

APPENDIX I

The Texas State Technical College at Waco Curriculum and Course Descriptions

FICE CODE: 003634

TSTI-WACO
SEMICONDUCTOR MANUFACTURING TECHNOLOGY
CURRICULUM 1991-1992

			PERIOD PER WEEK LEC.	LAB.	CR.	CONT. HRS. PER QTR.
FIRST QUARTER						
CHT	132	Topics in Chemistry and Metallurgy	2	4	3	72
CST	2060	Application Software	0	6	3	72
ENGL	104	Composition I	4	0	3	48
GT	102	Orientation	1	0	1	12
SMT	103	Semiconductor Process I	3	4	4	84
MATH	104	Intermediate Algebra	4	0	3	48
			14	14	17	336
SECOND QUARTER						
EEC	1004	DC Circuits	2	8	4	120
MGT	108	Intro To Metal Working Processes	2	6	4	96
MATH	124	Plane Trigonometry	4	0	3	48
LET	108	Electro-Optics Components	2	4	3	72
			10	18	14	336
THIRD QUARTER						
EEC	1104	AC Circuits	2	8	4	120
EEC	1404	Semiconductors I	2	8	4	120
SMT	104	Quality Control/SPC	2	0	2	24
SMT	203	Semiconductor Process II	3	6	4	108
			9	22	14	372
FOURTH QUARTER						
EEC	1503	Solid State Devices	2	4	3	72
EEC	1203	Digital Electronics	2	4	3	72
LET	305	Vacuum Systems I and Glass Fabrication	2	8	4	120
PHYS	105	College Physics	4	4	4	96
			10	20	14	360
FIFTH QUARTER						
ENGL	134	Interpersonal Communications	4	0	3	48
LET	317	Vacuum II	3	4	4	84
SMT	302	Manufacturing Methodologies	3	4	4	84
SMT	304	Contamination Control	3	4	4	84
			13	12	15	300
SIXTH QUARTER						
SMT	306	Preventive Maintenance	2	4	3	72
SMT	303	Semiconductor Process III	3	12	6	180
LET	320	Vacuum III	3	4	4	84
PYSC	104	General Psychology	4	0	3	48
			12	18	15	384
SEVENTH QUARTER						
GT	310	Elements of Supervision	2	2	3	48
SMT	312	Semiconductor Manufacturing Projects	1	8	3	108
SMT	314	Diagnostics/Troubleshooting of Automated Systems	2	6	4	96
EEC	1603	Microprocessors	2	4	3	72
			7	20	13	324
		Program Totals	75	126	102	2412

SEMICONDUCTOR MANUFACTURING TECHNOLOGY
COURSE DESCRIPTIONS
1991-1992

SMT 103 Semiconductor Process I (3-4-4) An introduction to Semiconductor Manufacturing Processes for the integrated circuit industry. This course will provide the basic understanding of materials, processes and equipment used in a wafer (Fab) fabrication. Emphasis will be the total process in lecture where the laboratory will undertake the safety, handling and basic process in step by step activities to produce a Solar Cell. This course will only process with limited hazardous materials required. Prerequisite: None.

SMT 104 Quality Control/SPC (2-0-2) A comprehensive study of the practical application of statistically sound methods to monitor (and continuously improve) individual manufacturing processes/equipment performance.

SMT 203 Semiconductor Process II (3-6-4) A continuation of SMT 103 into the intermediate areas of Process. This course will provide an in depth look at wafer preparation, oxidation/diffusion, CVD, thin films, photolithography, methodologies and etch methods. Students will be expected to produce working Solar Cells by the end of the term. Prerequisite: SMT 103, MATH 104, LET 305.

SMT 302 Manufacturing Methodologies (3-4-4) This course will provide a basic understanding of inventory/production control logistics and resultant product cycle time, and costs. There will be particular emphasis in understanding of individual productivity/efficiency as it relates to overall manufacturing success.

SMT 303 Semiconductor Process III (3-12-6) A more advanced and detailed study of each process learned in previous Process and Fabrication courses. Emphasis will be on producing the lightest yield, highest efficiency Solar Cell possible. Students will engage in all areas of the manufacturing procedure. Prerequisites: SMT 203, MATH 124, LET 317.

SMT 304 Contamination Control, Ion Implant (3-4-4) A detailed study of processes, materials and equipment in the following wafer fabrication areas: basic clean-room concepts and design, defect density analysis and control, wafer handling techniques and processing procedures, ion implant systems and dose control, ion ranges, annealing and diffusion of dopant impurities, shallow junction effects and gettering.

SMT 306 Preventative Maintenance (2-4-3) A study of the basic techniques, benefits and costs of a comprehensive equipment maintenance program, including the impact/improvement of manufacturing parameters such as mean-time-between-failures (MTBF), mean-time-to-repair (MTTR), machine availability and utilization.

SMT 312 Semiconductor Manufacturing Projects (1-8-3) A laboratory-intensive exercise to allow the student to apply integrated process and equipment knowledge to fully fabricate a working circuit on silicon. This project will require execution, analysis, and documentation of all relevant aspects of the manufacturing sequence, including final electrical test results.

SMT 314 Diagnostics/Troubleshooting of Automated Systems (2-4-3) A structured approach to the diagnosis and problem-solving methods of semiconductor processes/equipment to increase operational stability and availability.

SEMICONDUCTOR MANUFACTURING TECHNOLOGY
SUPPORT COURSES
1991-1992

CHT 132 Topics in Chemistry and Metallurgy (2-4-3) Fundamentals of chemistry including atomic structure, properties of elements, simple compounds, bonding, reactions and solutions involving acids, bases, and salts. Characteristics of photo-reactive materials. Structure and characteristics of crystalline elements and metals, including solid solutions, lattices, defects, diffusion, ion implants, and electrical behavior. Emphasis on safety and handling of hazardous materials.

CST 2060 Applications Software (0-6-3) A study of existing software packages that may be used by non-majors to solve problems within their respective technologies.

EEC 1004 DC Circuits (2-8-4) Fundamentals of direct current which includes the study of Ohm's Law, Watts Law, Kirchoffs Laws, superposition, thevenin, and Nortons Theorems, capacitance and inductance. Emphasis is placed on algebraic analysis of resistive networks and DC circuit measurement. Prerequisites: MATH 114 or concurrent enrollment.

EEC 1104 AC Circuits (2-8-4) Fundamentals of alternating current which includes series and parallel AC Circuits, phasors, capacitance and inductive networks, transformers, resonance, filter and pulse characteristics. Emphasis is placed on methods of analysis and circuit measurements. Prerequisites: EEC 1004 and MATH 124, or concurrent enrollment.

EEC 1203 Digital Electronics (2-4-3) An entry level course in digital electronics using TTL and CMOS Logic. The course covers numbering systems, logic gates, flip-flops, encoders, decoders, counters, registers, and a variety of other basic logic circuits. An introduction to A/D and D/A devices, and digital systems will be presented. Prerequisite: EEC 1104.

EEC 1404 Semiconductor Circuits (2-8-4) A study of diode and bipolar semiconductor devices. Analysis of static and dynamic characteristics, bias techniques, and thermal considerations of small, large and DC coupled signal amplifiers are emphasized. Prerequisites: EEC 1104 or concurrent enrollment.

EEC 1503 Solid State Devices (2-4-3) A study of various solid state devices which includes FET, UJT, SCR, triac and diac devices. Emphasis is placed on application, substitution and modification of circuit parameters. Prerequisites: EEC 1404

EEC 1603 Microprocessors (2-4-3) A basic course in microprocessor hardware, its architecture timing sequences, operation, and programming. Prerequisite: EEC1203

GT 102 Orientation (1-0-1) A course in which the student is acquainted with the organizational structure, history, policies, and course offerings at TSTI.

GT 310 Elements of Supervision (2-2-3) Study of supervisory duties and responsibilities in industrial organization and procedures for meeting these responsibilities. Prerequisite: Second-year classification.

LET 108 Electro-Optics Components (2-4-3) Properties, applications, and commercial sources of optical and mechanical components commonly used in industry. The laboratory will stress the specifying and ordering of components from manufacturers catalogs and technical publications.

LET 305 Vacuum I and Glass Fabrication (2-8-4) Elementary vacuum concepts and terminology. Physics of vacuum. Pumping principles, Pumps, Vacuum measurements, Vacuum gages, and auxiliary vacuum equipment. Elementary glass forming operations includes laboratory exercise in joining and bending of glass tubing.

LET 317 Vacuum Systems II (3-4-4) A study of industrial vacuum equipment including: mechanical pumps, oil-diffusion pumps, turbo-electric pumps, and vacuum instrumentation. Laboratory work includes disassembly, cleaning, and assembly of vacuum systems; and the deposition of metallic and dielectric coatings. Prerequisite: LET 305 or permission of Program Chairman.

LET 320 Vacuum III (3-4-4) Advanced leak detection techniques using Helium Leak Detectors and residual gas analyzer. A study in Vacuum deposition Technology and Systems. The course will enable the student to plan, repair, maintain, and test various systems which will include evaporators, e-guns, Ion plating, D.C. Sputtering and R.F. Sputters.
Prerequisites: LET 317

MGT 108 Introduction to Metal Working Processes (2-6-4) A course designed for the student enrolled in technologies that are associated with metal working processes to become familiar with metal working equipment and processes used industry. Equipment and processes introduced will include foundry, bench work, drills, grinders, lathe, milling machines, and demonstrations on Computerized Numerical control machining.

SEMICONDUCTOR MANUFACTURING TECHNOLOGY
ACADEMIC COURSES
1991-1992

ENGL 104 Composition I (4-0-3) [2304015135]
Principles and techniques of written composition, textual analysis, and critical thinking.
Prerequisite: ENGL 101 or equivalent as determined by English placement test.

ENGL 134 Interpersonal Communication (4-0-3) Theories and exercises in verbal and nonverbal communication with focus on interpersonal relationships.

MATH 104 Intermediate Algebra (4-0-3) [2701015237]
A study of relations and functions, inequalities, factoring, polynomials, rational expressions and quadratics with an introduction to complex numbers, exponential and logarithmic functions, determinants and matrices, sequences and series.
Prerequisite: MATH 101 or equivalent as determined by MATH placement test.

MATH 124 Plane Trigonometry (4-0-3) [2701015337]
Topics in trigonometric functions, right triangles, trigonometric identities, radian measure, graphs of periodic functions, and oblique triangles.
Prerequisite: MATH 104 or MATH 114

PHYS 105 College Physics I (4-4-4) [4008015339]
Principles and application of mechanics, wave motion, and heat with emphasis on fundamental concepts, problem solving, notation and units.
Prerequisite: MATH 124

PSYC 104 General Psychology (4-0-3) A survey of the major topics in psychology. Introduces the study of behavior and the factors that determine and affect behavior.

APPENDIX J

Center for Occupational Research and Development Model Curricula and Course Descriptions

Semiconductor Manufacturing Technology

Associate Degree Curriculum - Four Semester Schedule

Center For Occupational Research and Development

		LEC	LAB	CREDIT HRS
FIRST SEMESTER				
BC	Technical Algebra and Trigonometry	4	0	4
BC	Technical Communications	3	0	3
TC	Topics in Chemistry and Metallurgy	2	4	3
TC	DC and AC Circuits	3	6	5
SP	SMT Manufacturing Processes (Wafer Mfg., Contamination Control Oxidation/Diffusion)	3	3	4
		15	13	19
SECOND SEMESTER				
BC	Physics for Technicians	4	3	5
TC	Digital Electronics and Microprocessors	3	6	5
BC	Personal Computer Skills	1	4	2
TC	Semiconductor Electronics	3	3	4
SP	SMT Manufacturing Processes (Photolithography, Wet and Dry Etch	2	6	4
		13	22	20
THIRD SEMESTER				
TC	Production/Quality/Yield Improvement Inventory Control	3	3	4
TC	Mechanical, Vacuum, Laser Systems	3	3	4
TC	Electronic Test and Instrument Systems	2	0	2
SP	SMT Manufacturing Processes (Thin Films, Metallization, Chemical Vapor Deposition)	2	6	4
		10	12	14
FOURTH SEMESTER				
BC	Technical Communications	4	0	3
BC	Elements of Supervision	2	0	2
BC	Principles of Economics	2	0	2
TC	Automated Production Systems	3	6	5
SP	SMT Manufacturing Processes Ion Implant, Etching, Projects)	2	6	4
		13	12	16
	TOTALS	51	59	69

Curriculum Distribution	LEC	LAB	CREDIT
Legend: BC Basic Core	20(39%)	7(12%)	21(30%)
TC Tech Core	22(43%)	31(53%)	32(46%)
SP Specialty	9(18%)	21(36%)	16(23%)
TOTALS	51	59	69

Semiconductor Manufacturing Technology

Associate Degree Curriculum - Six Quarter Schedule

Center For Occupational Research and Development

		LEC	LAB	CREDIT HRS
FIRST QUARTER				
BC	Technical Communications	3	0	3
BC	Technical Algebra	3	0	3
BC	Personal Computer Skills	2	4	3
TC	Topics in Chemistry and Metallurgy	2	4	3
SP	Overview of Semiconductor Mfg.	2	3	3
		12	11	15
SECOND QUARTER				
BC	Physics for Technicians I	3	3	4
TC	DC and AC Circuits	3	6	5
SP	SMT-I: Wafer Prep., Contamination Control, Oxidation, Diffusion/Doping	3	4	4
BC	Technical Trigonometry	3	0	3
TC	Mechanical Systems	2	3	3
		14	16	19
THIRD QUARTER				
BC	Physics for Technicians II	3	3	4
TC	Semiconductor Electronics I	2	6	4
TC	Digital Electronics	2	3	3
SP	SMT-II: Photolithography, Wet & Dry Etch	3	6	5
		10	18	16
FOURTH QUARTER				
TC	Semiconductor Electronics II	2	6	4
TC	Vacuums and Lasers	2	3	3
TC	Electronic Test and Instrumentation	3	6	4
SP	SMT-III: Chemical Vapor Depostion (CVD) Thin Films, Metalization, Ion Implant	3	4	4
		10	19	16
FIFTH QUARTER				
BC	Group Communication	3	0	3
TC	Vacuums II	2	3	3
TC	Automated Production Systems	2	6	4
TC	Production/Quality/Yield Improvement and Inventory Control	3	3	4
BC	Technical & Business Writing	4	0	3
		14	12	17
SIXTH QUARTER				
BC	Principles of Economics	3	0	3
BC	Elements of Supervision	2	2	3
TC	Microprocessor Controls	2	4	3
TC	Diagnostics/Troubleshooting of Automated Systems	2	6	4
SP	Projects in SMT Manufacturing	1	6	3
		10	18	16
	TOTALS	70	94	98

Curriculum Distribution	LEC	LAB	CREDIT
Legend: BC Basic Core	29(41%)	12(13%)	32(33%)
TC Tech Core	29(41%)	59(63%)	47(48%)
SP Specialty	12(17%)	23(24%)	19(19%)
TOTALS	70	94	98

Semiconductor Manufacturing Technology Program
Course Descriptions

BASIC CORE (BC)

Composition I (3-0-3) Principles and techniques of written composition, textual analysis, and critical thinking.

College Algebra (3-0-3) A study of quadratics; polynomial, rational, logarithmic and exponential functions; systems of equations, progressions; sequences and series; matrices and determinants.

Personal Computer Skills (2-4-3) Students learn the fundamentals of starting a computer, loading specific programs and manipulating data. Word processing, spreadsheets and databases will be explored.

Physics for Technicians—A Systems Approach (3-3-4) This course teaches students the principles of physics by explaining similarities between systems–mechanical, electrical, fluid, and thermal. For example, the concept of force is taught as it applies to each system before another concept is discussed. Students find this manner of learning easier as it allows a transfer of knowledge from one system to another. This course contains 12 different concepts; six are taught in the first quarter of PFT and six in the second.

Plane Trigonometry (3-0-3) Topics in trigonometric functions, right triangles, trigonometric identities, radian measure, graphs of periodic functions, and oblique triangles.

Group Communication (3-0-3) Discussion and small group theories and techniques as they relate to group process and interaction.

Principles of Economics (3-0-3) History, development and application of macro and micro economic theory underlying the production, distribution and exchange of goods and services, utilization of resources; analysis of value and prices; national income analysis; fiscal policies; monetary and banking theory and policy. Distribution of income; labor problems; international economics; economics systems. Attention given to the application of economic principles to economic problems.

Elements of Supervision (2-2-3) Study of supervisory duties and responsibilities in industrial organization and procedures for meeting these responsibilities.

Technical and Business Writing (4-0-3) Technical and Business Writing teaches students to prepare letters and memos for distribution within and without a company. Students also learn to prepare technical reports that are organized in a logical manner. The use of good grammar and accurate spelling is stressed. This course emphasizes the importance of accurate written communication to students who are ready to graduate.

Physics for Technicians (3-3-4) This is a continuation of the second-quarter course.

TECHNICAL CORE (TC)

Vacuums and Lasers (2-3-3) Students are introduced to the equipment and techniques used to attain the reduced pressures (vacuums) required to produce high-quality, pure materials for manufacturing semiconductors. Students will also have opportunities to assemble the necessary equipment and to troubleshoot problems that occur with the vacuum-producing system.

Production/Quality/Yield Improvement and Inventory Control (3-3-4) This course introduces students to several ideas and practices that combine to maximize production while minimizing cost of production stressed are quality and yield improvement by use of tools such as statistical process control and knowing what design and production parameters are and how they interact to affect production.

Preventive Maintenance (2-6-4) Preventive Maintenance teaches students the importance of keeping records and following manufacturers' recommended maintenance procedures for establishing an ongoing plan for keeping machinery and equipment in operable condition. Students will develop a complete preventive maintenance program for a given assigned set of equipment.

Automated Production Systems (2-6-4) This course introduces students to the integrated production-line concept. Students will examine and test interfaces between machines and their controllers and interfaces with other machines. They will be given the opportunity to interconnect machines, set them up to operate, program them, and place them in operation; then, as troubleshooting becomes necessary, students will determine the source of problems and correct the problems.

Electromechanical Devices and Systems (3-4-4) This course is designed to provide the student with a working knowledge of electronic devices and to develop the student's ability to assemble and test basic solid-state components and vacuum-tube circuits. Topics include active electrical devices, analog devices, digital devices, input-output devices, analog systems, and digital systems.

Design and Run of Experiments (2-0-2) Design and Run of Experiments provides students with the opportunity to design a test procedure to evaluate a specific characteristic about a component or system. Students will conduct the experiment and then evaluate the test to determine if they learned the data they expected to and if the criterion being tested is satisfactory or not.

Electrical Test and Instrumentation In Electrical Test and Instrumentation students will learn the fundamentals of installing, setting up, calibrating, and placing instrumentation systems in service. Students will apply previously gained knowledge and skills using test instruments as they monitor and troubleshoot the new process monitoring and controlling systems.

Vacuums II (2-3-3) A continuation of vacuums and lasers with major emphasis on vacuum systems. Students explore advanced high vacuum techniques; they assemble vacuum systems and troubleshoot from a system approach.

Topics in Chemistry and Metallurgy (2-4-3) Fundamentals of chemistry including atomic structure, properties of elements, simple compounds, bonding, reactions and solutions involving acids, bases, and salts. Characteristics of photo-reactive materials. Structure and characteristics of crystalline elements and metals, including solid solutions, lattices, defects, diffusion, ion implants, and electrical behavior. Emphasis on safety and handling of hazardous materials.

Digital Electronics (2-3-3) An entry-level course in digital electronics using TTL and CMOS Logic. The course covers numbering systems, logic gates, flip-flops, encoders, decoders, counters, registers, and a variety of other basic logic circuits. An introduction to A/D and D/A devices, and digital systems will be presented.

Semiconductor Electronics (2-6-4) A study of diode and bipolar semiconductor devices. Analysis of static and dynamic characteristics, bias techniques, and thermal considerations of small, large and DC coupled signal amplifiers is emphasized.

Mechanical Systems (2-3-3) Include actuators and drive mechanisms such as belts, chains and gears. These courses will also offer instruction in such actuators as mechanical linkages and cam systems. Basic components of vacuum, pneumatic and hydraulic systems. Hands-on labs show techniques for calculating chain and belt length; measurement and adjustment of backlash between gear teeth; installation procedures for seals and bearings; practices for working with aerobic and anaerobic sealants; and the use of precision measuring equipment such as dial calipers and dial indicators.

Electronic Test and Instrumentation Systems (2-3-3) A study of the various types of test instruments available to the technician and their proper usage. Additionally, the student will study common types of instrumentation equipment in process control loops.

DC and AC Circuits (3-6-5) Fundamentals of direct current which includes the study of Ohm's law, Watts law, Kirchhoff's Law, superposition, Thevenin's, and Norton's Theorems, RC and RL time constants. Emphasis is placed on algebraic analysis of resistive networks and DC circuit measurement. Fundamentals of alternating current includes series and parallel AC circuits, phases, capacitance and inductive networks, transformers, rescnance, filter and plus characteristics. Emphasis is placed on methods of analysis and circuit measurements.

SPECIALTY CORE (SP)

Overview of Semiconductor Manufacturing (2-3-3) An introduction to the semiconductor industry and an overview of integrated circuit manufacturing. This course will provide a basic understanding of materials, processes, and equipment currently used in wafer fabrication.

Semiconductor Manufacturing Projects (1-6-3) A laboratory-intensive exercise to allow the student to apply integrated process and equipment knowledge to fully fabricate a working circuit on silicon. This project will require execution, analysis, and documentation of all relevant aspects of the manufacturing sequence, including final electrical tests results.

SP Course Descriptions

SMT-I: Wafer Preparation, Contamination Control, Oxidation, Diffusion (3-4-4)

A detailed study of precesses, materials and equipment in the following wafer fabrication areas:

- Wet chemical cleaning, basic clean-room concepts, wafer contamination and defect density analysis
- Oxidation techniques and systems, oxide properties and defects
- Diffusion mechanisms of dopants and measurement techniques, and epitaxy

SMT-II: Photolithography, Wet and Dry Etch (3-6-5)

A detailed study of precesses, materials and equipment in the following wafer fabrication areas:

- Pattern transfer principles, photoresist chemistry (negative and positive resist), principles of optical lithography, reticle cleaning, surface preparation, resist application, exposure systems, develop methods, inspection procedures and critical line-width control
- Wet chemical etchants and their properties, plasma etching, ion beam and reactive ion etching techniques, control of rates and selectivity, edge profiles and geometry considerations.

SMT-III: Chemical Vapor Deposition (CVD), Thin Films, Metalization, Ion Implant (3-4-4)

A detailed study of processes, materials, and equipment in the following wafer fabrication areas:

- Atmospheric and low-pressure chemical vapor deposition techniques and systems, plasma-assisted depositions
- Deposited films, single and multilayer metalization techniques
- Ion implant systems and dose control, ion ranges, annealing and diffusion of dopant impurities, shallow junction effects and gettering

APPENDIX K

Press Notices

TSTI WACO

TECH TALK

Vol. 5, No. 3
March 20, 1990

Business and Industry Newsletter

Students Save Program Big Bucks!

By Monica Ortega, Public Information and News Intern

Teamwork was the key in saving Mechanical Engineering Technology $6,000 on a machine the program needed.

Kenneth Kornele of Belton, and Paul Petmecky of San Antonio, two students in the MET program, designed and built a machine with the help of their instructor, Paul Raborn.

The machine they built is called a sheet metal nibbler. It is designed to cut sheet metal up to 16 gauges in thickness into different shapes and sizes.

The nibbler acts like a paper hole punch, but instead of cutting paper, it cuts metal.

It was designed and built to be used for a Manufacturing Materials and Processes class.

The program had bought a hand-held sheet metal nibbler which broke right away because of poor design for withstanding its intended uses.

Raborn said a better machine was needed to take its place, but the program could not afford the $6,000 it would cost to buy it at the time.

"We couldn't buy anything that could do the job, so we had to build our own," Raborn said.

Kornele and Petmecky's goal was to redesign a better sheet metal nibbler to handle tougher uses.

Kornele said he and Petmecky, who are student workers in the program, each put in 15 hours of work a week on the machine, finishing the project in one quarter.

The materials used to build the machine came from surplus parts belonging to the school, Kornele said.

Raborn said the project was successful with the engineering help of George Gray, MET program chairman, and MET Instructor Thomas Middleton.

The calculations in fitting the pieces together needed to be precise in order for the machine to work, Raborn said. Some of the measurements could not even deviate three-thousandths of an inch; (that is the width of a human hair.)

Now that the machine is successfully completed, Raborn speaks of Kornele and Petmecky with praise.

"There are a lot of good students in the program (MET), but these are exceptional students," Raborn said.

Petmecky said he is finishing his fifth quarter at TSTI and would like to continue his education in mechanical engineering at Southwest Texas State University in San Marcos when he graduates.

Kornele, who is also finishing his fifth quarter, said he would like to work in mechanical engineering for General Dynamics or some other large corporation that would help him continue his education toward a bachelor's degree.

Raborn and the entire MET staff are proud of the finished product and welcome anyone who is interested in seeing the nibbler to stop by the program.

Issue Highlights:

Tech Talk
Newsletter
Published monthly by
TSTI/Waco
Public Information and News
3801 Campus Drive
Waco, Texas 76705
(817) 867-4833, or 1-800-792-TSTI

TSTI/Waco Administration

Don E. Goodwin
President

Ben Younger
Interim Dean of Student Services

Steve Malbrough
Manager of Instructional Support Services

Dr. William Cox
Acting Dean of Instruction

[illegible]

TSTI [illegible]

[illegible]

TSTI and CORD Win Contract For Training

TSTI/Waco and the Center for Occupational Research and Development, also known as CORD, have landed a $417,000 contract to train workers at Sematech, an Austin-based semiconductor research consortium.

The grant comes from the U.S. Department of Education to design a program for workers inside the nation's "clean rooms," the sterile manufacturing lines where computer chips are made.

CORD is splitting the grant with TSTI/Waco, which will serve as the new program's pilot site. President Goodwin said students can begin taking the new classes toward an associate degree in the fall of 1990.

Rosie Oswald, Sematech's manufacturing supervisor, said the program is only one of a handful of educational programs in the country aimed at the chip industry.

"It's so much more technical than it used to be that we need a higher level of operator," Oswald said.

TSTI History

To celebrate TSTI's 25th Anniversary, each month we will highlight historical facts:

Did you know...
By 1964, James Connally Air Force Base had a total of 4,034 assigned personnel and an annual payroll of over $19 million. It was at this time that the Secretary of Defense Robert S. McNamara announced that the base would be phased out by July 1966. The people of Waco were shocked because of the drastic effect it would have on Waco's economy. Civic leaders immediately started thinking of ways to ease the blow. A special committee was formed to begin solving the problems the loss would create. Harry Provence, Harlon Fentress and J.H. Kultgen were responsible for attempts to save the base, by visiting President Lyndon B. Johnson, and going to Washington, D.C. to try to stop the closing. By February 1965, discussions between Gen. Earl Rudder, president of Texas A&M University, and Gov. John Connally had resulted in the idea to turn the base into a technical institute. These men realized the need for better education and training to meet the manpower demands within the state.

Calendar of Events

March 17-18	Board of Regents Meeting, TSTI/Waco
March 18	Wind Festival and Charity Sail
March 19	Faculty Grad. Gown Sizing, Bookstore
March 22-23	FHT Club Bedding Plant Sale
March 25	KCTF Campus Commentary, CST/IPT
March 26	DC Power Supply Seminar, IDEAS Center
March 27	Faculty Grad. Gown Sizing, Bookstore
March 27-28	Chemical Emergency Response Class
March 28	Career Awareness Day, University High
March 28	Campus Commentary, Ch. 34, CST/IPT
March 30-31	VICA Contest
March 31	Postmark deadline for next TASP Test
March 31	Girl Scouts Visit TSTI/Waco
April 1	Daylight Savings Time, (turn clocks up)
April 3 7 pm	Women's Club Meeting, Student Center
April 4	Career Awareness Day, Waco High
April 5-6	TSTI Development Foundation Meeting
April 6-7	Sneak Preview
April 13	Good Friday, Holiday!
April 14-15	Texas Air Expo
April 18-19	Industry Career Days
April 22	KCTF Campus Commentary, DDT
April 25	Secretaries Day
April 25	Campus Commentary, Ch. 34, DDT
April 28	TASP Test

Tribune-Herald
LOCAL
SUNDAY
March 18, 1990
SECTION B
Obituaries 3B
Marketplace 4B

Gramm to battle for Fort Hood

By DARLENE McILVAINE
Tribune-Herald staff writer

U.S. Sen. Phil Gramm said Saturday in Waco that he still is fighting for the survival of a Fort Hood division and is concerned about reports that troops withdrawn from Europe won't be reassigned to Fort Hood.

Gramm, R-College Station, took time out of a briefing on a new semiconductor program at Texas State Technical Institute to talk about the Fort Hood situation.

On Wednesday, Maj. Gen. John Greenway, the Army's assistant deputy chief of staff, gave written testimony to a House committee that "contained a presumption or a policy" that the Conventional Forces in Europe treaty would deactivate troops as they came home instead of reassigning them, Gramm said.

Gramm said there have been conflicting reports since Wednesday, adding that he and U.S. Rep. Marvin Leath, D-Waco, will try to meet with the secretary of the Army and the Arms Control and Disarmament Agency this week for a clarification.

"We are going to nail down where we are and agree on a joint strategy with one objective — try to protect Central Texas from the impact that would clearly occur, costing us thousands of jobs and generating a fallout of millions of dollars in negative economic impact, if we deactivated the 2nd Armored Division and did not have troops to replace them with on any kind of timely basis," Gramm said.

Confusion about the issue is not intentional, he said. "It is a question of the right hand not knowing what the left is doing."

Gramm said he and Leath have an alternative plan if troops returning from Europe can't be reassigned. If they are reassigned, he said he believes Fort Hood has a good chance of receiving "backfill."

"If we do have an INF treaty agreed to with the Soviet Union which does deactivate troops being pulled out of Europe ... obviously, backfilling at that point would be impossible.

"But it would not be impossible at that point for the Army to go back and say the decision to deactivate the 2nd Armored Division was a de-

See FORT, Page 10B

European troop cuts would hurt Fort Hood

By DREW PARMA
Tribune-Herald staff writer

Fort Hood's future looks a little bleaker after testimony by an Army deputy chief of staff about a proposed force reduction treaty in Europe.

Major Gen. John Greenway told *The Dallas Morning News* this past week that a pact being negotiated with the Soviets over reduced levels of conventional forces in Central Europe might not allow troops withdrawn from Germany to be relocated to Fort Hood or other domestic bases. According to Greenway, the troops withdrawn from Germany under a Conventional Forces in Europe treaty as it stands now would be demobilized, not relocated.

In other words, in the treaty as it is written now, there would be no "backfill" of Europe-based troops to fill in at the giant Army base after the 2nd Armored Division is demobilized.

"I've always been suspicious of the old 'backfill' line," said

See PROPOSED, Page 2B

LOCAL / TEXAS

Reports of whether U.S. soldiers returning from Europe will be stationed at Fort Hood have been conflicting, U.S. Sen. Phil Gramm says.

Fort Hood a concern, Gramm says

☐ From Page 1B

cision that was based on a belief that the troops being brought home from Europe would be used to backfill.

"If, in fact, those troops were going to be deactivated, the decision concerning the 2nd Armored Division was a mistake," he said.

Gramm added: "Obviously, the secretary of the Army can make the decision on terms of deactivation. I can't help but believe, however, that we will have some impact on the debate, since I'm on the appropriations committee that provides their money and since Marvin (Leath) is on the authorization committee that authorizes the way they can spend it."

Defense Secretary Dick Cheney has recommended that the 2nd Armored Division be dismantled under a larger base-closing proposal announced in January. Gramm said he doesn't think Cheney went back on his commitment to give Fort Hood first claim on forces coming home from Europe.

After discussing Fort Hood, Gramm toured the TSTI facilities where a semiconductor curriculum will be taught that industry and school officials hope will become a model for the nation.

Gramm said he hopes the semiconductor curriculum will spawn other programs to further train technicians involved in the $8 billion superconducting super collider to be built near Waxahachie.

The local project, which is being funded by a $419,000 grant from the U.S. Department of Education, will involve TSTI, the Center for Occupational Research and Development, Semiconductor and Manufacturing Technology — or Sematech — and the National Coalition of Advanced Technology Centers.

Dan Hull, a representative of the Waco-based CORD, said the project began when Sematech, a consortium of 14 U.S. semiconductor manufacturers, approached the firm with a need for new technicians.

Hull said he contacted Gramm and TSTI about the project. TSTI was chosen to participate, he said, because it has "60 to 70 percent" of the technology needed to train students in semiconductor technology and because the school and CORD have worked well together in the past.

Tribune-Herald

THURSDAY
Dec. 7, 1989

14A

TSTI, Waco firm win nod to train Sematech workers

From staff and wire reports

A Waco firm and Texas State Technical Institute have landed a $417,000 contract to train workers at Sematech, an Austin-based semiconductor research consortium.

The program is part of a unique worker training program for manufacturers of computer chips.

The research consortium, formed to improve the chip-making process, said Wednesday it will assist the Waco-based Center for Occupational Research and Development, also known as CORD, in devising the training curriculum.

CORD, a non-profit organization, has received a $417,000 grant from the U.S. Department of Education to design a program for workers inside the nation's "clean rooms," the sterile manufacturing lines where computer chips are made.

CORD is splitting the grant with TSTI-Waco, which will serve as the new program's pilot site.

Rosie Oswald, Sematech's manufacturing supervisor, said the Waco program is one of only a handful of educational programs in the country aimed at the chip industry, known for its razor-thin margins of error and its reliance on advanced — and often complicated — manufacturing equipment.

"It's so much more technical than it used to be that we need a higher level of operator," Oswald said.

"Sematech's expertise in semiconductor research and development will play a vital role in the success of this project," said CORD President Dan Hull. "Working together in this high technology partnership with Sematech will give us the edge we need to effectively train the technicians of the future."

While the Waco effort is unusual in its focus on chip workers, it is similar to a proposal by Austin economic development officials, who have promised U.S. Memories Inc. a $5 million training and research center if it decides to locate its proposed computer-chip plant in the city.

That center would be a 20,000-square-foot building and would be operated by Austin Community College, state documents show.

Oswald said Sematech officials are volunteering their time to the CORD effort and will help the organization pinpoint areas to be included in the training.

Officials say they already plan to present courses in inorganic chemistry, high vacuum systems, optics, semiconductor materials, electronics and electromechanical systems.

Don Goodwin, president of TSTI-Waco, said students can begin taking the new classes toward an associate degree in the fall of 1990.

Computer chip consortium dissolves

By CATALINA ORTIZ
The Associated Press

SANTA CLARA, Calif. — U.S. Memories, a joint venture created to expand America's small share of the computer chip market, is dissolving because of inadequate financial support from the industry, it was announced Monday.

"What we saw was an unwillingness to support sufficient equity as well as purchase commitments to go forward," said company president Sanford L. Kane.

At the same time, he criticized the industry for concentrating on short-term tactics rather than long-term strategy.

U.S. Memories, hailed by American companies when it was formed last June to invest $1 billion in a chip-making plant, decided to terminate the venture after a meeting Wednesday in Dallas with the original seven investing companies and four other potential backers.

Two original backers, International Business Machines Corp. and Digital Equipment Corp., maintained their major commitment to the venture, but Kane said the others were not willing to put up enough money to fund the venture's first plant or agree to buy enough of its 4-megabit dynamic random access memory chips, or DRAMs.

"From early on, we all knew the viability of U.S. Memories was contingent on (that)," Kane said at a news conference.

American computer companies depend heavily on foregin manufacturers — primarily those in Japan — for DRAMS, a common form of chip important in computers, household appliances and the U.S. defense system. They often are compared to crude oil in their importance to industry.

U.S. Memories, which estimated that American companies currently supply no more than 10 percent of the American demand for the chips, hoped to produce 25 percent of the DRAMS needed by U.S. computer companies.

Inadequate supply and high cost of DRAMs prompted the formation of U.S. Memories last year. In addition to IBM and Digital, original investors included Hewlett-Packard Co., Intel Corp., Advanced Micro Devices Inc., National Semiconductor Corp. and LSI Logic.

But since then, supply has increased and the price has dropped, largely because several new companies, including Samsung of South Korea, have begun making the chips, according to analysts. U.S. companies needing DRAMs apparently no longer think they have a problem, Kane said.

J. Richard Iverson, president of the American Electronics Association, which supports efforts to increase the U.S. share of the chip market, said, "I don't know what we could have done more."

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Sematech, supercollider funds OK'd

By SETH KANTOR
Cox News Service

WASHINGTON — In a major victory for Texas interests, the White House has approved full federal funding of $100 million for Sematech and $393 million for the superconducting supercollider, sources reported Monday.

Although Sematech and the supercollider had faced serious threats of budget cutbacks, sources said President Bush on Jan. 29 would recommend full funding for the two projects when he releases his proposed spending plan for fiscal 1991, the 12-month period that begins Oct. 1.

At the same time, U.S. Rep. Jake Pickle, D-Austin, said, "There is no evidence the budget will include Bergstrom Air Force Base on any list of military bases to be closed" in the effort to reduce defense spending in 1991.

Sources on Capitol Hill and close to Gov. Bill Clements said they have received confirmation from the White House that Sematech and the supercollider will receive the spending level sought by Texas backers of the two major projects.

Two months ago, opposition reportedly was growing within the Defense Department and the president's Office of Management and Budget to a plan to divide the cost of Sematech equally between the microchip industry and the Pentagon.

Widespread reports of attempts by government officials to cut back on Sematech funding in the new budget were termed "alarming" by Miller Bonner, Sematech spokesman.

Strong arguments were made during budget discussions, according to several Washington sources, that the semiconductor industry should pick up a larger share of the financial burden because American-based firms ultimately will profit from research and development under way at Sematech's Austin facility.

But in the end, Budget Director Richard Darman and Defense Secretary Richard Cheney agreed to continue the fourth year of a five-year pact between the government and the industry consortium, which was formed to re-establish U.S. leadership in advanced high-tech processes.

While Sematech was under review, some of the president's budget-cutters and other scientists lobbying for scarce federal research dollars attempted to slow down construction of the multi-billion-dollar supercollider facility.

Meanwhile, Pickle said he could "lay to rest" speculation in the Austin area that Bergstrom might be forced to shut down because of military belt-tightening in the new budget.

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BUSINESS

Thursday, December 7, 1989 Austin American-Statesman

Sematech plans training program for employees who assemble chips

By Kyle Pope
American-Statesman Staff

Sematech officials said Wednesday the consortium is planning a unique worker training program for computer chip manufacturing companies.

The Austin-based research consortium, formed to improve the chip-making process, said it will assist the Waco-based Center for Occupational Research and Development, CORD, in devising the curriculum for the training effort.

Work on the program will begin shortly in Waco and later will be offered to colleges and universities across the country.

CORD, a non-profit organization, has received a $417,000 grant from the U.S. Department of Education to design a program for workers inside the nation's "clean rooms," the ultra-sterile manufacturing lines where computer chips are made.

CORD is splitting the grant with the Texas State Technical Institute in Waco, which will serve as the pilot site for the new program.

Rosie Oswald, Sematech's manufacturing supervisor, said the Waco project is one of only a handful of educational programs in the country aimed at the chip industry, known for its razor-thin margins of error and its reliance on advanced — and often complicated — manufacturing equipment.

"It's so much more technical than it used to be that we need a higher level of operator," Oswald said.

Oswald said Sematech officials are volunteering their time to the CORD effort and will help pinpoint the technology areas that will be included in the training programs.

Don Goodwin, president of TSTI in Waco, said students can begin taking the classes toward an associate degree in the fall.

"Once the curriculum is developed, we'll make it available to any educational institution that wants it," Goodwin said.

Xerox executive chosen to head Sematech group

By MICHAEL HOLMES
The Associated Press

William J. Spencer succeeds the late Robert Noyce as Sematech president.

AUSTIN — William J. Spencer, a microelectronics researcher and Xerox Corp. vice president, Wednesday was chosen president and chief executive of the Sematech semiconductor research consortium.

Spencer, 60, succeeds Robert Noyce, who died of a heart attack.

Noyce, co-inventor of the integrated circuit and a pioneer in the semiconductor industry, had headed the Austin-based chip manufacturing research center since 1988.

Spencer will play an important role in guiding Sematech's research. He also will serve as a key spokesman for the microchip industry on issues such as federal funding and bolstering the semiconductor industry and its support companies against foreign competitors.

"The national mission we must accomplish is key to America's competitiveness and key to preserving our standard of living for our children and our grandchildren," Spencer told Sematech's Austin workforce after his appointment Wednesday.

The nonprofit Sematech was created by 14 companies in 1988 to regain the world lead in microchip manufacturing technology for the United States by 1993.

The consortium employs 650 people in Austin. [illegible] has an annual budget of $[illegible]00 million, which is supported [illegible]ember companies and by m[illegible] funds from the Defense Ad[illegible]ed Projects Research Agency.

Spencer brings to his new post a lengthy background in microelectronics research.

He was group vice president and senior technical officer for Xerox Corp. in Stamford, Conn.

Spencer joined Xerox in 1981, when he became manager of the company's integrated circuit laboratory at its Palo Alto Research Center. He formerly worked for the government-funded Sandia National Laboratories in Livermore, Calif., and Albuquerque, N.M., and was a research professor of medicine at the University of New Mexico.

Holder of a master's degree in mathematics and a doctorate in physics from Kansas State University, Spencer began his career in 1959 with Bell Laboratories.

Sematech is developing advanced semiconductor manufacturing methods, equipment and materials. Research results are given to the member companies and the federal government for commercial and military applications.

As CEO, Spencer will direct Sematech's advance semiconductor manufacturing staff and will serve as the consortium's primary liaison to its 14 member companies and the government.

Member companies include Advanced Micro Devices, AT&T, DEC, Harris Corp., Hewlett-Packard, IBM, Intel, LSI Logic, Micron Technology, Motorola, NCR, National Semiconductor, Rockwell International and Texas Instruments.

Vo-Tech: Dynamic Programs for Diverse People

Micron workers gain technical knowledge in 'Tech Prep'

By Amy Stahl
BSU News Services

Twenty workers at Micron Technology Inc. will have an opportunity to improve their technical know-how with the help of a program to begin in March at Boise state. "Tech Prep," a five-month, pilot program offered through the College of Technology, is considered to be on "the cutting edge" of vocational technical education.

Modeled after a program developed by the Texas-based Center for Occupational Research and Development, Tech Prep was created in response to the needs of employers competing in today's global marketplace, Cook says. "Employers want men and women who have a broad-based knowledge of the principles behind technology, and a practical understanding of technology's application in the work place. They want, and need, employees who can cope with accelerating technological change."

Tech Prep students will explore the basics in computers, technical graphics, applied communication and mathematics, principles of technology, elec-tronics, hydraulic and pneumatic systems, and quality control.

Specifically, the program includes three phases of instruction and training: pre-tech, tech core and tech specialty. In pre-tech, the students learn basic skills in refresher courses such as math, applied physics, computers and more. Next, they will participate in hands-on courses in electronics and other technical fields. Finally, they will develop specialized skills by focusing on high-tech fields.

Students in the program will continue to work on their regular line snifts at Micron while attending courses from 5:30-8:30 p.m. at BSU.

Upon completion of the program the workers are expected to be more eligible for promotion within their industry and better-equipped to pursue college degrees, Cook says.

Micron's Betty Sims believes Tech Prep exemplifies the type of educational training that is desperately needed by workers at her company—and others. "We have a hunch that we have employees who need a better fundamental grasp of the basics and who would like to go on to an AA (associate's) degree but need more background," says Sims, manager of training and education programs at Micron. "This is going to equip our people by giving them a broader base."

Tech Prep comes on the heels of an AA program that began several weeks ago at Micron. From tests interested workers took, it was determined that some would benefit form first enrolling in Tech Prep, before attending the AA classes.

Cook is optimistic about the success of tech Prep, based on the experiences of other institutions. A similar program at Lorain County (Ohio) Community College enjoyed phenomenal success.

See MICRON, Page 21C

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: Programs for Diverse People

Micron———

Continued from Page 7C

The area suffered from a dire need to retrain workers laid off during the recent Rust Belt economic crisis, and Lorain program placed 100 percent of the workers in new jobs. "It was able to retool and retrain all these dislocated workers in a high-technology field," Cook says.

Ultimately, she says, BSU would like to see Tech Prep available at the high school level, and offer it regularly through the College of technology. "We intend to implement it in our curriculum for students in electronics, drafting and construction management, because some students seem to be deficient in these basic areas," Cook says.

MICRON WORKERS GET 'TECH' TRAINING

Twenty workers at Micron Technology will have an opportunity to improve their technical know-how with the help of a program to begin in March at Boise State. "Tech Prep" is a five-month, pilot program offered through the College of Technology.

Tech Prep students will learn basic skills in refresher courses such as math, applied physics, computers and more. Then the students will participate in hands-on courses in electronics and other technical fields. And finally, they will develop specialized skills by focusing on high-tech fields.

Students in the program will continue to work on their regular line shifts at Micron while attending evening courses at BSU.

Upon completion of the program, the workers are expected to be more eligible for promotion within their industry and better equipped to pursue college degrees, says Sharon Cook, acting associate dean of the College of Technology. ☐

BSU SEARCHES FOR THREE DEANS

Boise State is nearing the end of national searches to fill vacancies for deans in three of the university's seven colleges.

The positions opened for a variety of reasons. Tom Stitzel, business, will return to teaching next fall, John Entorf, technology, died last summer, and Richard Hart, education, will retire at the end of this semester.

Search committees in business and technology spent the fall semester combing resumes to arrive at lists of candidates for interviews. Applications for the education position closed in mid-January.

The selection of all three deans is expected in February or early March. ☐

MANELINE DANCERS THIRD IN DIVISION

Like the Bronco football team, the ManeLine dancers improved their record this "season" with a third-place finish in Division I of the NCAA National Collegiate Cheerleading and Pom Dance Championship in Dallas. The squad finished fourth in the competition last year.

The 20-member team competed against Division I teams such as Southern Methodist University and the University of Miami. The University of Missouri won the contest. Long Beach State University placed second.

Adviser/coach Julie Stevens said she was proud of the dancers, who worked hard to collect the funds needed to participate in the championship. The team raised $12,000 from fans, businesses and the BSU athletic department. ☐

Focus Magazine, Boise State University, Vol. XVI, No. 2, Winter 1991.

APPENDIX L

Promotion/Dissemination of Semiconductor Manufacturing Technology Materials

Promotion of Semiconductor Manufacturing Technology and Dissemination of Materials

Meetings

SRC Competitiveness Foundation Workshop:
Rensselaer Polytechnic Institute
Troy, New York
May 30-31, 1991

Microelectronic Manufacturing Education

An Operating Training Program

30-minute presentation by Dr. Walter Edling, Vice President for Programs, Center for Occupational Research and Development (CORD)

National Coalition of Advanced Technology Centers (NCATC)
Waco, Texas

NCATC Fall Conference
November, 7-9, 1991, Waco, Texas
Current Developments in Technical Course Materials
by Dr. Walter Edling

Ninety percent of presentation on Semiconductor Manufacturing Technology program at the Texas State Technical College at Waco (TSTC) and worker retraining for Micron Technology, Inc. at Boise State University (BSU)

NCATC Summer Conference

June 21-23, 1990, Camden, Jew Jersey

Semiconductor or Manufacturing Technician

"Manufacturing Specialist"

Associate Degree and Retraining Programs

by Dr. Walter Edling

Applied Materials Corporation
Education Council meeting
Austin, Texas
November 18, 1991

Technician Training for the Semiconductor Devices Industry

Semiconductor Manufacturing Technology/Technician Training Project

2-1/2-hour presentation and discussion of Applied Materials with staff and area educators by Mr. Bob Thompson, CORD.

Semiconductor Manufacturing Technology
Dissemination Conference
May 9-10, 1991, TSTC
by CORD, TSTC, SEMATECH, NCATC

Semiconductor Manufacturing Technology
Technician Training Project Status Report
Technical Advisory Committee and Curriculum Committee joint meetings
October 9-10, 1990
February 3-4, 1991
by CORD, TSTC, SEMATECH, NCATC

National Association of Industry Specific Training Directors
March 8-9, 1990, Austin, Texas
Overview of early Semiconductor Manufacturing Technology program and the baseline management by
Mr. Tom Liberty of SEMATECH

Texas Instruments Production Managers meeting
Texas Instruments, Dallas Texas
February 14, 1991
Presentation on the Semiconductor Manufacturing Technology curriculum as of February 7, 1991, by Mr. Bob Thompson

National Conference for Occupational Education
Seventeenth Annual Conference
October 20-23, 1991
San Antonio, Texas
Transformations:
Technical Literacy Training
Retraining for Technology
Tech Prep Bridge Program
by Dr. Walter Edling
Included discussion of Micron worker training at BSU

National Council on Community Services and Continuing Education
Annual Fall Conference
October 21, 1991, Corpus Christi, Texas

Transformations:
Preparing Workers for Entry-Level Employment through Technology Literacy Training
by Mr. Alan Sosbe, Research Associate, CORD

Included discussion of Micron worker training at BSU

North Harris County College District
Boot Camp Program
October 9, 1991, Houston, Texas

Transformations:
Retraining for Technology Incorporating Applied Academics
by CORD staff, including Dr. Walter Edling

Included discussion of Micron worker training at BSU

Promotion of Semiconductor Manufacturing Technology and Dissemination of Materials

Publications

Edling, Walter, and Alan Sosbe. "Technology Training for Dislocated Workers Transformations". *Economic Development Commentary.* National Council for Urban Economic Development. Winter 1991, Volume 14, Number 4.

Stahl, Amy. "Micron Workers Gain Technical Knowledge In Tech Prep". *Idaho Business Review, Inc.* February 11, 1991, page 7C.

"Micron Workers Get Tech Training". *FOCUS.* Biose State University. Volume XVI, Number 2, Winter 1991.

Hull, Dan, and Dale Parnell. "Anatomy of a Transformation," *Tech Prep Associate Degree: A Win/Win Experience.* CORD, Waco, TX, 1991, pp 214-223.

NCATC Newsletter. The National Coalition of Advanced Technology Centers. Waco, TX. "CORD Receives Major Federal Educational Grant; NCATC to Participate in Project. " December 1989, page 3.

Update on the Semiconductor Project. June 1990, page 2.

NCATC Members to Test Curriculum on Semiconductor Manufacturing Technology. December 1990, page 2.

Update: Semiconductor Technician Training. March 1991, page 2.

NCATC Ahead of Money. August 1991, page 1.

Semiconductor Manufacturing Technology: TSTC Accepts the Challenge. October 1991, page 1.

APPENDIX M

Evaluation Report (Glen Bounds)

TECHNICIAN TRAINING FOR THE SEMICONDUCTOR MICRODEVICES INDUSTRY

EVALUATION REPORT

DR. GLEN I. BOUNDS
EXTERNAL EVALUATOR

NOVEMBER 16, 1991

TECHNICIAN TRAINING FOR THE SEMICONDUCTOR MICRODEVICES INDUSTRY

EVALUATION REPORT

I. Introduction

II. Summary

III. Procedure

IV. Results

A. The Effectiveness and Value of the Specific Project Tasks and Deliverables.

1. Project Advisory Committee
2. Preliminary Task List and Curriculum Design
3. Validation of the Task List
4. Forecast of Future Training Needs
5. Design Curriculum/Develop Courses
6. Implement Retraining Classes
7. Implement Associate Degree in Semiconductor Manufacturing Technology
8. Provide for Semiconductor Training Program Replication
9. Evaluate Project
10. Disseminate Information
11. Design a Model for Technical Training Development
12. Report Project Progress

B. The Achievement of the Four Primary Objectives of the Project.

V. Recommendations

INTRODUCTION

The Technician Training for Semiconductor Microdevices Industry project, or the Semiconductor Manufacturing Technology (SMT) project, as it is now called, is designed to produce associate degree technicians who are capable of advancing to senior technician positions and with additional training, to maintenance technician or engineering levels. In addition to the need for an SMT associate degree program, there is a pressing need for using portions of the curriculum materials for retraining and upgrading of skills for employees currently working in semiconductor manufacturing settings.

The SMT curriculum is divided into the following major components:

- Basic Core (BC)
  - Composition
  - College Algebra
  - Personal Computer Skills
  - Physics for Technicians--A systems approach
  - Plane Trigonometry
  - Group Communication
  - Principles of Economics
  - Elements of Supervision
  - Technical and Business Writing
  - Physics for Technicians
- Technical Core (TC)
  - Vacuums and Lasers
  - Production/Quality/Yield Improvement and Inventory Control
  - Preventive Maintenance
  - Automated Production Systems
  - Electromechanical Devices and Systems
  - Electrical Test and Instrumentation
  - Vacuums II
  - Topics in Chemistry and Metallurgy
  - Digital Electronics
  - Semiconductor Electronics
  - Mechanical Systems
  - Electronic Test and Instrumentation Systems
  - DC and AC Circuits
- Specialty Core (SP)
  - Overview of Semiconductor Manufacturing
  - Semiconductor Manufacturing Projects

The Semiconductor Manufacturing Technology (SMT) associate degree program was developed and is being pilot tested at Texas State Technical College (TSTC). Concurrently, a group of employees from Micron Technology, Inc. was identified for participation in a retraining project in cooperation with Boise State University (BSU). The employees identified did not have a sufficient technical background to enter into advanced operator training nor directly into the SMT program. Instead, they were enrolled in the Center for Occupational Research & Development's (CORD) Transformations program, a tech-prep. bridge curriculum prior to entering the SMT curriculum.

The evaluation component of this project was designed to provide an outside assessment of the program as implemented. The primary questions addressed in the evaluation effort included:

A. The effectiveness and value of the specific project tasks and deliverables.

B. The achievement of the four primary objectives of the project.

Both the SMT Associate Degree Project and the Tech-Prep Retraining Project were funded through a grant from the U.S. Department of Education, Office of Vocational and Adult Education. The approval received was for a cooperative high technology demonstration project.

SUMMARY

The Semiconductor Manufacturing Technology (SMT) project has been very successful, and the curriculum which has been produced and pilot tested should be implemented in other areas of the country where there is a concentration of semiconductor industries. A key factor which contributed significantly to the success of the project is the cooperative effort combining the talents and expertise of five major organizations:

- **CORD** - A nonprofit organization with a 20-year track record in designing/disseminating technician curricula in new and emerging technologies.
- **TSTC** - The statewide institute in Texas with the responsibility for creating and delivering technician education/training for emerging technologies.
- **SEMATECH** - A manufacturing R & D consortium of 14 major semiconductor industries having locations throughout the United States. Micron Technology, Inc., a member of the SEMATECH consortium, participated in the retraining segment of the project in cooperation with BSU.
- **NCATC** - (The National Coalition for Advanced Technology Centers) is a coalition of 60 technical and community colleges throughout the U.S. with specific commitment to sharing resources and curricula for customizing technical education/training.
- **BSU** - A state university in Idaho which is committed to providing technician level education/training to industry in the Boise area.

The SMT curriculum is highly technical, costly equipment intensive and specific to the semiconductor industry. As such, it should not be offered except in areas where there is sufficient demand to justify the program. The retraining of employees currently in the semiconductor industry appears to have similar potential to that of the two-year associate degree program.

PROCEDURE

The procedure for the evaluation segment of this SMT program included review of written materials about the program and discussions discussions with staff at CORD, BSU, and Micron Technology, Inc. During the site visits to BSU and TSTC, classes were observed; administrators, faculty, and students were interviewed; and laboratory facilities and equipment were examined. Also, during the visit to Boise, a tour was made of the Micron Technology, Inc. facility. One Project Advisory Committee meeting was observed at SEMATECH in Austin, Texas.

Data relative to the Semiconductor Manufacturing Technology program were requested and obtained during the site visits to the two educational institutions. Additional data were provided by project staff at CORD.

RESULTS

A. Effectiveness and value of the specific project tasks and deliverables:

1. Project Advisory Committee (PAC)
   The attached PAC list represents the vanguard of the semiconductor manufacturing industry. Assisting in and responding to each of the PAC meetings were representatives from TSTC and CORD. The PAC remained actively involved in the project throughout its duration.

SEMICONDUCTOR MANUFACTURING TECHNOLOGY

ADVISORY COMMITTEE
April, 1990

Bill Brennan
AMD
2706 Montopolis Drive
Austin, Texas 78741

Mike Hill
AMD
2706 Montopolis Drive
Austin, Texas 78741

Joe Carroll IBM
1000 River Road
Essex Junction, Vermont 05452

Wayne Cronin
Motorola
10803 Graymere Court
Austin, Texas 78739

Bernard Fay
Semi/SEMATECH
2706 Montopolis Drive
Austin, Texas 78741

John Georgick
Texas Instruments
MS 385
13353 Floyd Road
Dallas, Texas 75265

Jim Laibl
Human Resource Manager
Harris Semiconductor
MS 62-003
P. O. Box 883
Melbourne, Florida 32901

Tom Liberty
IBM/SEMATECH
Burlington, Vermont
802/769-1971

Vijay Persuad
Harris Semiconductor
2706 Montopolis Drive
Austin, Texas 78741

John Waite NSC
MS 27-100
P. O. Box 58090
Santa Clara, California 95052-8090

Skip Weed
SEMATECH/Motorola
2706 Montopolis Drive
Austin, Texas 78741

Keith R. Whiteside
Training and Education
Semiconductor Group
Texas Instruments
MS 3909
7800 Banner Drive
P. O. Box 650311
Dallas, Texas 75251

2. Preliminary Task List and Curriculum Design

The original task information was obtained from SEMATECH and member companies. An advisory sub-committee (list attached) was then formed to address task validation and expansion.

SEMICONDUCTOR MANUFACTURING TECHNOLOGY

ADVISORY SUB-COMMITTEE

TASK VALIDATION AND EXPANSION
May, 1990

Member	Main Contribution	Company
Bill Ligon	Photolithography	Harris Corporation
Jason Lee	CVD	NCR
Jake Theisen	Plasma Etching	AMD
Dan Grelinger	Metrology	A T & T
Keiffer Elliott	Oxidation/Diffusion/CVD	SEMATECH
Jose Chacon	Water Cleaning	A T & T
Joel Barnett	Implant	LSI Logic
Tom Liberty	All Tasks	IBM
Jack Luby	All Tasks	A T & T
Wayne Hughes	All Tasks	NCR

3. Validation of the Task List

The task list was then reviewed by the PAC and fifty-four other technical professionals for validation. Final editing of the task list was done by staff from CORD and TSTC.

4. Forecast of Future Training Needs

Since enough time has not elapsed for students to have completed the program, placement is still an unknown. However, according to information received during student interviews, hose students who are nearing completion are being interviewed with great interest by multiple companies. The demand for semiconducto s in the computer, aerospace, and telecommunications industries continues to expand; and with such growth, the demand for technicians appears to be continually on the increase.

Responses received from an industry survey conducted October, 1990, include the following:

- In an MDP Associates study for the Portland (Oregon) Development Commission, (11) companies were interviewed. These companies expect to hire 500 entry level persons next year.

- Micron Technology, Inc. emphasized the need for their operators who are interested in moving into technician roles to receive training with a significant emphasis on mathematics, physics, chemistry, communications skills, and knowledge of computers and integrated circuits processes.

- Memorandums from five SEMATECH managers echo the Micron request.

- TSTC Laser Electro Optics and Instrumentation Departments indicate that semiconductor plants that are laying off operators, continue to hire their technician trainees.

5. Design Curriculum/Develop Courses

The validated task list was used as the basis for the curriculum design. The curriculum has been designed in three different patters: a four-semester schedule; a six-quarter schedule; and a seven-quarter schedule. Each of the patterns includes a basic core, a technical core, and a specialty core. The seven-quarter schedule also allows for an additional component of electives. (See attached curriculum patterns.)

Semiconductor Manufacturing Technology
Associate-Degree Curriculum • Four-Semester Schedule
Center For Occupational Research and Development

		LEC	LAB	CREDIT HRS
FIRST SEMESTER				
BC	College Algebra and Plane Trigonometry	4	0	4
BC	College English	3	0	3
TC	Topics in Chemistry and Metallurgy	2	4	3
TC	DC and AC Circuits	3	6	5
SP	SMT Manufacturing Processes (Wafer Mfg., Contamination Control Oxidation/Diffusion)	3	3	4
		15	13	19
SECOND SEMESTER				
BC	Physics for Technicians	4	3	5
TC	Digital Electronics and Microprocessors	3	6	5
BC	Personal Computer Skills	1	4	2
TC	Semiconductor Electronics	3	3	4
SP	SMT Manufacturing Processes (Photolithography, Wet and Dry Etch)	2	6	4
		13	22	20
THIRD SEMESTER				
TC	Production/Quality/Yield Improvement Inventory Control	3	3	4
TC	Design and Run Experiments	2	0	2
TC	Mechanical, Vacuum, Laser Systems	3	3	4
TC	Electronic Test and Instrument Systems	2	0	2
SP	SMT Manufacturing Processes (Thin Films, Metallization, Chemical Vapor eposition)	2	6	4
		12	12	16
FOURTH SEMESTER				
BC	Technical Communications	4	0	3
BC	Elements of Supervision	2	0	2
BC	Principles of Economics	2	0	2
TC	Automated Production Systems	3	6	5
SP	SMT Manufacturing Processes (Ion Implant, Etching, Projects)	2	6	4
		13	12	16
	TOTALS	53	59	71

Curriculum Distribution	LEC	LAB	CREDIT
Legend: BC Basic Core	20 (38%)	7 (13%)	21 (30%)
TC Technical Core	24 (45%)	31 (53%)	34 (48%)
SP Specialty Core	9 (17%)	21 (40%)	16 (22%)
TOTALS	53	59	71

Semiconductor Manufacturing Technology

Associate-Degree Curriculum - Six-Quarter Schedule

Center For Occupational Research and Development

		LEC	LAB	CREDIT HRS
FIRST QUARTER				
BC	College English Composition	3	0	3
BC	College Algebra	3	0	3
BC	Personal Computer Skills	2	4	3
TC	Topics in Chemistry and Metallurgy	2	4	3
SP	Overview of Semiconductor Mfg.	2	3	3
		12	11	15
SECOND QUARTER				
BC	Physics for Technicians I	3	3	4
TC	DC and AC Circuits	3	6	5
SP	SMT-I: Wafer Prep., Contamination Control, Oxidation, Diffusion/Doping	3	4	4
BC	Plane Trigonometry	3	0	3
TC	Mechanical Systems	2	3	3
		14	16	19
THIRD QUARTER				
BC	Physics for Technicians II	3	3	4
TC	Semiconductor Electronics I	2	6	4
TC	Digital Electronics	2	3	3
SP	SMT-II: Photolithography, Wet and Dry Etch	3	6	5
		10	18	16
FOURTH QUARTER				
TC	Semiconductor Electronics II	2	6	4
TC	Vacuums and Lasers	2	3	3
TC	Electronic Test and Instrumentation	3	6	4
SP	SMT-III: Chemical Vapor Depostion (CVD) Thin Films, Metalization, Ion Implant	3	4	4
TC	Design and Run Experiments	2	0	2
		12	19	18
FIFTH QUARTER				
BC	Group Communication	3	0	3
TC	Vacuums II	2	3	3
TC	Automated Production Systems	2	6	4
TC	Production/Quality/Yield Improvement and Inventory Control	3	3	4
BC	Technical and Business Writing	4	0	3
		14	12	17
SIXTH QUARTER				
BC	Principles of Economics	3	0	3
BC	Elements of Supervision	2	2	3
TC	Microprocessor Controls	2	4	3
TC	Diagnostics/Troubleshooting of Automated Systems	2	6	4
SP	Projects in SMT Manufacturing	1	6	3
		10	18	16
	TOTALS	72	94	100

Curriculum Distribution	LEC	LAB	CREDIT
Legend: BC Basic Core	29 (40%)	12 (13%)	32 (32%)
TC Technical Core	31 (43%)	59 (63%)	49 (49%)
SP Specialty Core	12 (17%)	23 (24%)	19 (19%)
TOTALS	72	94	100

Semiconductor Manufacturing Technology

Associate-Degree Curriculum - Seven-Quarter Schedule
Center for Occupational Research and Development

		LEC	LAB	CREDIT HRS
FIRST QUARTER				
BC	College English Composition	3	0	3
BC	College Algebra	3	0	3
BC	Personal Computer Skills	2	4	3
TC	Topics in Chemistry and Metallurgy	2	4	3
SP	Overview of Semiconductor Mfg.	2	3	3
		12	11	15
SECOND QUARTER				
BC	Physics for Technicians I	3	3	4
	Approved Elective	2	4	3
BC	Plane Trigonometry	3	0	3
TC	Mechanical Systems	2	3	3
		10	10	13
THIRD QUARTER				
BC	Group Communication	3	0	3
BC	Physics for Technicians II	3	3	4
TC	DC and AC Circuits	3	6	5
TC	Vacuums and Lasers	2	3	3
		11	12	15
FOURTH QUARTER				
BC	Principles of Economics	3	0	3
TC	Digital Electronics	2	3	3
TC	Automated Production Systems	2	6	4
TC	Vacuums II	2	3	3
SP	SMT: Wafer Prep., Contamination Control, Oxidation, Diffusion/Doping	3	4	4
		12	16	17
FIFTH QUARTER				
TC	Semiconductor Electronics I	2	6	4
TC	Electromechanical Devices and Systems	3	4	4
TC	Production/Quality/Yield Improvement and Inventory Control	3	3	4
SP	SMT: Photolithography, Wet and Dry Etch	3	6	5
		11	19	17
SIXTH QUARTER				
TC	Semiconductor Electronics II	2	6	4
	Approved Technical Elective	2	4	3
TC	Design and Run Experiments	2	0	2
SP	SMT: Chemical Vapor Deposition (CVD), Thin Films (Metalizations), Ion Implant	3	4	4
		9	14	13
SEVENTH QUARTER				
BC	Technical and Business Writing	4	0	3
BC	Elements of Supervision	2	2	3
TC	Microprocessor Controls	2	4	3
TC	Electronic Test and Instrumentation	3	6	4
SP	Projects in SMT Manufacturing	1	6	3
		12	18	16
	TOTALS	77	100	106

Curriculum Distribution	LEC	LAB	CREDIT
Legend: BC Basic Core	29 (38%)	12 (12%)	32 (30%)
TC Technical Core	32 (42%)	57 (57%)	49 (46%)
SP Specialty Core	12 (15%)	23 (23%)	19 (18%)
Electives	4 (5%)	8 (8%)	6 (6%)
TOTALS	77	100	106

6. Implementing Retraining Classes

Micron Technology, Inc., as a member of SEMATECH, was chosen as the site for pilot testing a retraining program. Boise State University, located a few miles away, cooperated in providing staff, facilities, and equipment for offering retraining to a selected group of Micron employees. The employees were recommended by their supervisors for participation in the pilot project. The 20 employees selected were considered to be unprepared for further training in the Micron plant as well as the regular SMT curriculum; therefore, they were offered a 302 hour adult-tech-prep curriculum taken from CORD's Transformations program. The program consisted of:

- Applied Mathematics
- Principles of Technology
- Graphics for Technicians
- Mechanical Devices and Systems
- Fluid Power
- Personal Computers
- Applied Communications
- Introduction to Chemistry

The training was scheduled as follows:

- Three hours per day, 4 days a week, for 26 weeks,
- Micron paid 2.5 hours release time 4 days a week,
- Employees contributed 2.0 hours of personal time 4 days a week for class attendance and study time,
- Employees worked 12 hour shifts -- 3 days "on", 3 "off",
- Most of the employees worked overtime. Several were "on-call."

Of the 20 employees, from quite varied academic and experiential backgrounds, 19 completed the training. One student dropped due to illness.

Pre-tests and post-tests were administered in three of the classes. Those students who took both the pre-test and post-test showed mean improvements of 27 percent in Mathematics; 39.3 percent in Fluid Power; and 21.6 percent in Principles of Technology as reflected in Chart 1. Charts 2 and 3 reflect an overall mean improvement of 9.4 percent from a raw score of 38.64 to 41.04 on ACT's ASSET test of basic skills.

A consensus of the students was that the schedule was entirely too unrealistic for maximum achievement of the program objectives. The strenuous schedule obviously affected the rate of attendance, as shown in Chart 4. Several of the students expressed a desire for more mathematics to better prepare them for the science and technical courses which follow.

An indication of the effectiveness of the program is reflected in the fact that all nineteen of the employees who completed the tech-prep program are now participating in further training in the company. Discussions among CORD, BSU, and Micron indicate an interest in beginning another group of employees in a repeat offering of the program. Additionally, there is interest in beginning the SMT curriculum with the program completers.

CHART 1

TECH PREP

CLASS PRE/POST TEST SCORES

Student	Math */20 Pre	Post	Graphics */5 Pre	Post	Mech Dev */5 Pre Post	Fluid Power */10 Pre	Post	PT */20 Pre	Post
3261	14	na	na	5	na	na	na	15	16
3816	7	16	na	4	1	1	7	10	12
2044	17	16	na	5	3	8	8	na	na
6789	14	16	na	na	1	4	na	8	8
3699	10	15	na	5	3	6	8	6	na
4260	10	16	na	4	3	8	8	11	16
181	13	16	na	5	1	7	na	na	10
3238	14	na	na	5	na	na	9	10	11
2574	10	na	na	5	na	na	7	7	12
3029	12	na	na	na	na	na	8	10	9
6810	10	na	na	5	na	na	8	6	11
6092	17	na	na	na	na	na	na	11	na
5886	9	na	na	5	na	8	9	11	15
5754	11	16	na	5	4	6	8	9	11
6522	14	14	na	5	3	6	8	10	15
1386	5	12	na	5	1	4	7	6	7
2640	9	17	na	3	3	4	7	6	4
559	5	13	na	4	0	2	7	11	na
3869	13	15	na	na	3	na	8	9	15
2709	15	15	na	5	2	5	7	10	14

Note: Pre-Test for the Graphics course was not administered.

CHART 2

BSU "TECH PREP" PARTICIPANTS PRE & POST ASSET SCALE SCORES

	Pre - Test					Post - Test					
Student	Writ.	Read	Algebra	Num.	Avg.	Writ.	Read	Algebra	Num.	Avg.	Diff.
181	50	51	34	38	43.25	50	45	40	45	45.00	1.75
1386	30	35	27	34	31.50	35	35	32	37	34.75	3.25
2044	42	48	32	47	42.25	43	46	40	50	44.75	2.50
2574	40	35	36	36	36.75	45	43	32	44	41.00	4.25
2640	35	40	34	38	36.75	37	41	34	45	39.25	2.50
2709	39	39	31	42	37.75	37	39	42	50	42.00	4.25
559	28	27		36	30.33	33	40	26	34	33.25	2.92
3029	45	46	32	48	42.75	46	41	40	47	43.50	0.75
3238	54	53	45	46	49.50	49	48	44	47	47.00	-2.50
3261	49	44	47	44	46.00	50	46	48	52	49.00	3.00
3699	45	38	27	45	38.75	39	39	36	43	39.25	0.50
3816	29	32	26	32	29.75	31	30	27	34	30.50	0.75
3869	44	46	31	41	40.50	44	46	31	48	42.25	1.75
4260	31	34	34	38	34.25	40	36	44	48	42.00	7.75
5754	38	37	29	40	36.00	38	34	40	38	37.50	1.50
5886	37	39	32	37	36.25	41	41	40	45	41.75	5.50
6092	52	51	36	51	47.50						
6522	42	46	27	40	38.75	52	48	29	47	44.00	5.25
6789	41	38	27	39	36.25	43	45	31	46	41.25	5.00
6810	42	41	26	43	38.00	39	39	40	49	41.75	3.75
TOTAL:	40.65	41.00	32.26	40.75	38.64	41.68	41.16	36.63	44.68	41.04	

BSU "TECH PREP" PARTICIPANTS PRE AND POST ASSET TEST RESULTS DIFFERENCE IN SCALE SCORES

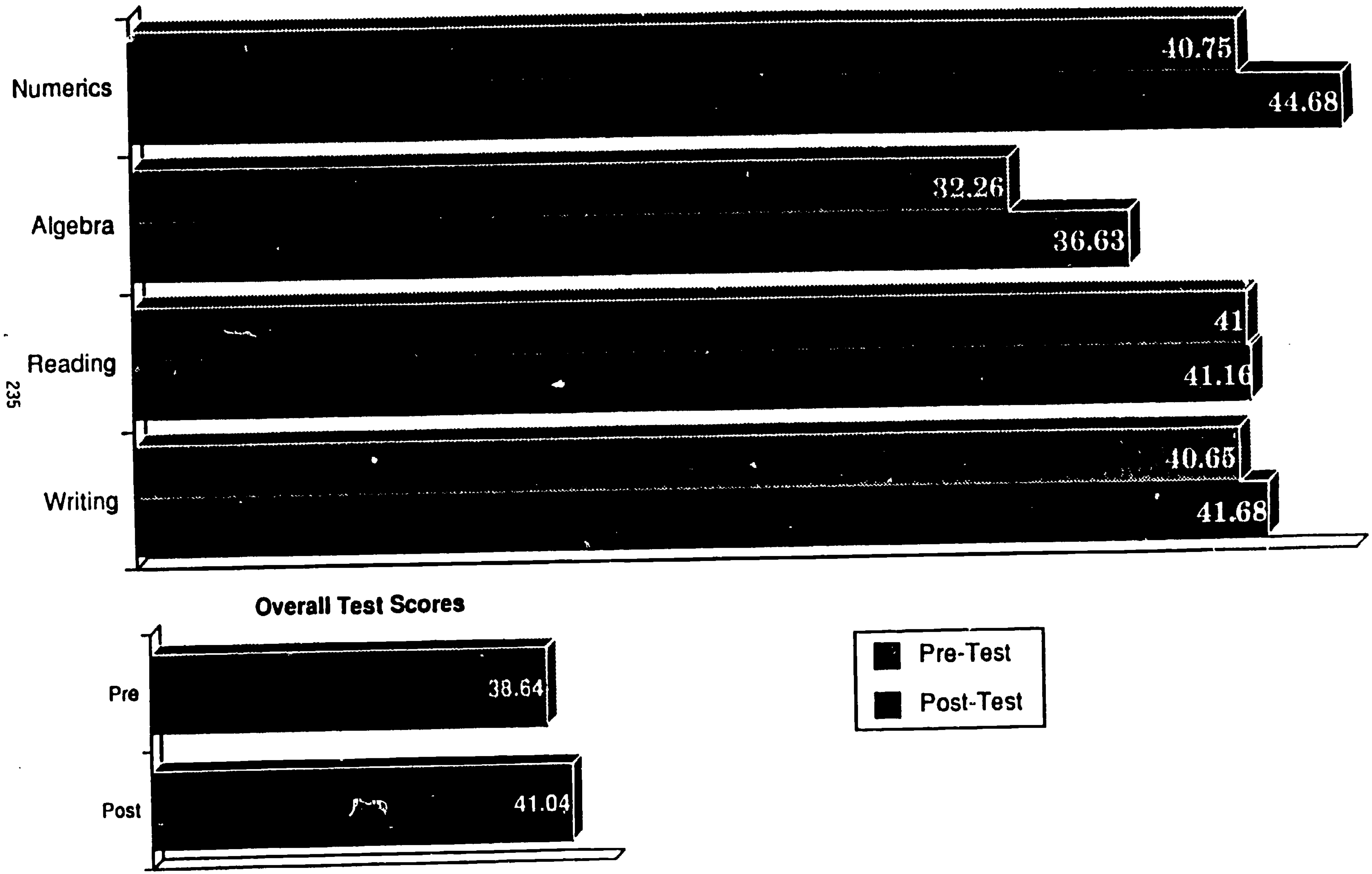

CHART 3

CHART 4

TECH PREP

SUMMARY OF STUDENT ATTENDANCE

Student	MATH 42	GRAPHICS 31.5	COMP. 30	COMM. 19.5	MECH DEV. 21	FLUID POWER 28	CHEM 31.5	PT 84	TOTAL 287.5
3261	35	28	26	16.5	14	21	28	74	242.5
3816	38.5	24.5	26	15	17.5	28	31.5	84	265
2044	42	21	26	12.5	21	21	25.5	45.5	214.5
6789	42	28	26	15	17.5	28	31.5	81	269
3699	38.5	24.5	24	16.5	14	24.5	30	81	253
4260	42	24.5	22	15	17.5	28	24.5	73	246.5
181	42	21	18	10.5	17.5	17.5	17	34.5	178
3238	42	28	20	13.5	10	21	10.5	64.5	209.5
2574	35	31.5	24	15	17.5	28	17.5	67.5	236
3029	31.5	24.5	17	15.5	10.5	17.5	28	60	204.5
6810	35	31.5	26	13.5	21	28	28	75	258
6092	35	17.5	10	7.5	3.5	0	0	12	85.5
5886	38.5	31.5	25.5	15	21	24.5	30.5	81	267.5
5754	38.5	31.5	24	15	17.5	28	28	73	255.5
6522	42	31.5	30	18	21	28	31.5	84	286
1386	42	21	26	9	14	24.5	21	71	228.5
2640	38.5	24.5	12	7.5	17.5	28	23.5	74	225.5
559	42	31.5	30	19.5	14	28	31.5	84	280.5
3869	42	24.5	26	16.5	14	26	31.5	80	262.5
2709	42	31.5	28	16.5	17.5	24.5	27	74	261

7. Implement an Associate Degree in Semiconductor Manufacturing Technology

TSTC had the primary responsibility for developing the curriculum and course outlines; identifying required equipment, training aids, reference materials, and textbooks; setting up a laboratory; recruiting the first class of students; and pilot testing the program with students at TSTC.

TSTC has met all the requirements of the project. The one weakness has been in student recruitment. Less than ten declared SMT majors have participated in the first year of the program. Approximately twenty students from other related technology programs, such as Laser Electro-Optics Technology, have taken SMT courses. This is seen as an appropriate and viable method of recruiting technically prepared students for the program. Brochures are available, and expanded recruitment efforts have been initiated.

Student attrition has been almost 50%. Reasons for not persisting have included family and financial problems, fear of chemicals used in the laboratory, and the difficulty of the curriculum. More extensive assessment is now being conducted prior to accepting students into the program.

A laboratory space was retrofitted and with the use of a donated filter system, the laboratory should reach a clean-room status of perhaps Class 50,000 or better; certainly more than adequate for classroom purposes.

8. Provide for Semiconductor Training Program Replication

A complete curriculum guide made up of course materials, reference lists, training aids lists, suggested textbook list, and equipment list is currently well under way and will be available by January 1992. All materials and resources will be readily tranportable to other locations as needed. Replication of this program requires serious consideration due to the high cost of setting up a laboratory and the highly specialized nature of the technology; required only in locations where there are concentrations of semiconductor manufacturers.

9. Evaluate Project

A comprehensive evaluation of the project is hampered by the fact that the students in the two-year, associate degree program have not had time to complete the program. Interviews with the students at TSTC revealed that they are confident they have benefitted by being a part of the pilot project in that they have enjoyed the hands-on experience of installing and making ready the equipment in the laboratory.

Observing the early student attrition rate at TSTC has caused the program staff to make extra efforts at assessing students prior to accepting them into the program. Pre-tests and post-tests were administered in most of the classes in the retraining program. To enhance the program evaluation, this practice needs to be done in all the classes.

10. Disseminate Information

Presentations about the program have already been made at several national and state-wide conferences including:

SRC Competitiveness Foundation Workshop:
Renssalaer Polytechnic Institute, Troy, NY
May 30-31, 1991
Microelectronic Manufacturing Education
An Operating Training Program
30 minute presentation by Dr. Walter Edling, CORD

National Coalition of Advanced Technology Centers (NCATC)

NCATC Summer Conference, June 21-23, 1990, Camden, N.J.
Semiconductor or Manufacturing Technician
"Manufacturing Specialist"
Associate Degree and Retraining Programs
by Dr. Walter Edling, CORD

NCATC Fall Conference, Nov. 7-9, 1991, Waco, TX
Current Developments in Technical Course Materials
by Dr. Walter Edling, CORD
Ninety percent of presentation on SMT program at TSTC and and worker retraining for Micron at BSU

Applied Materials Corporation
Education Council Meeting, November 18, 1991, Austin, TX

Technician Training for the Semiconductor Devices Industry
Semiconductor Manufacturing Technology/Technician Training Project
2-1/2 hour presentation and discussion at Applied Materials with staff and area educators by Bob Thompson, CORD.

Semiconductor Manufacturing Technology
Dissemination Conference
Texas State Technical College, May 9-10, 1991, Waco, TX
by CORD, TSTC, SEMATECH, NCATC

Semiconductor Manufacturing Technology
Technician Training Project
Status Report Meetings
October 9, 1990
February 4, 1991
CORD, TSTC, SEMATECH, NCATC

National Conference for Occupational Education
Seventeenth Annual Conference, October 20-23, 1991
San Antonio, TX

Transformations:
Technical Literacy Training
Retraining for Technology
Tech Prep Bridge Program
Dr. Walter Edling, CORD
Included discussion of Micron Worker training at BSU.

National Council on Community Services and Continuing Education
Annual Fall Conference, October 21, 1991, Corpus Christi, TX

Transformations:
Preparing Workers for Entry-Level Employment Through Literacy Training
by Alan Sosbe, CORD
Included discussion of Micron Worker training at BSU.

North Harris County College District
Boot Camp Program, October 9, 1991, Houston, TX

Transformations:
Retraining for Technology
Incorporating Applied Academics
by CORD Staff, including Dr. Walter Edling
Included discussion of Micron Worker training at BSU.

Publications include:

NCATC Newsletter
The National Coalition of Advance Technology Centers

December 1989, page 3
CORD Receives Major Federal Educational Grant;
NCATC to Participate in Project

June 1990, page 2
Update on the Semiconductor Project

December 1990, page 2
NCATC Members to Test Curriculum on Semiconductor Manufacturing Technology

March 1991, page 2
Update: Semiconductor Technician Training

August 1991, page 1
NCATC Ahead of Money
(two line mention of TSTC part of SMT project)

October 1991, page 1
Semiconductor Manufacturing Technology: TSTC Accepts the Challenge

11. Design a Model for Technical Training Development

The cooperative process used in this project should serve as a model for developing technical training programs. The integrated efforts of industrial consortia, educational institutions, and independent technical researchers provides state-of-the-art, cutting-edge technological information for designing the very best possible curricula.

12. Report Project Progress

Comprehensive and timely reports have been submitted to the United States Department of Education. These reports have also been a part of the information shared in the Dissemination Conference.

3. The Achievement of the Four Primary Objectives of the Project

1. To work with industry experts and educators to design and develop a curriculum that will meet the need for semiconductor technician training.

   This objective was accomplished in an exemplary manner utilizing the very best resources available from the semiconductor industry, well-known technical educational institutions, and an independent research and development center.

2. To implement and test the curriculum at a technical college with a track record of working with the semiconductor industry.

   TSTC has fully implemented the SMT program and has fulfilled this objective for the project. Curriculum materials have been tested and revised as needed. The experience they have gained in setting up and equipping an SMT laboratory will be very valuable for other institutions wishing to implement the program.

3. To disseminate information on the retraining courses and the complete program, including the curriculum, and encourage its replication at community and technical colleges throughout the country.

   Presentations at national conferences has been accomplished and will continue to happen. The final curriculum materials are in draft form and will be ready for dissemination by January. Professional quality brochures describing the program are available. Since the associate degree program has not completed its first cycle, a journal article on the program is premature. Such articles are planned by CORD and TSTC upon completion of the first program cycle.

4. To create a model for the development of technician training programs for new and emerging technologies.

   The process used in developing the SMT associate degree program and the retraining program has been chronicled by CORD, TSTC and BSU and can be made available upon request. The process of incorporating efforts of a manufacturing consortium, a technical college, an area university, and an independent research and development center, provided for optimum expertise in designing the program.

RECOMMENDATIONS

1. The Semiconductor Manufacturing Technology program development model is one which should be replicated, particularly in high technology program areas where industrial consortia can be called upon to provide a vanguard of resources and expertise in a cooperative relationship with educational institutions and research centers.

2. The scheduling for the Transformations, tech-prep, retraining program should to be reviewed to determine ways to provide a more reasonable time frame for students who are also full-time employees. There must be more time provided for class preparation between work hours and class sessions.

3. A strategic student recruitment plan for the SMT program is needed. Communicating the potential of this highly specialized program, even to highly capable students, can be very difficult. The industrial demand is apparent. Recruitment of capable students must match this demand.