

*Providing our customers with structurally integrated electronics
for advanced sensing, communications, and signals intelligence.*



MesoPlasma™ Direct Write Fabrication of Conformal, Harsh Environment Sensors

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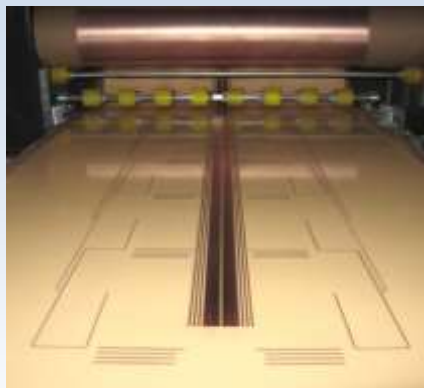
Passive Wireless Sensor Tag Workshop

July 27-28, 2011

Houston, TX

Company Overview

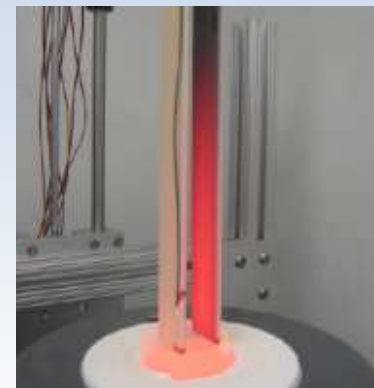
Providing our customers with structurally integrated electronics for advanced sensing, communications, and signals intelligence.



Direct Write Fabrication



High Precision Coatings



Contract R&D

❑ Founded in 2002

- Direct Write Products
- Contract R&D Services
- Application Development

❑ Facilities and Capabilities

- DW Fabrication Facilities
- Laser Processing and CNC Machining
- Sensor and Material Characterization

Corporate Office & East Coast Development Lab

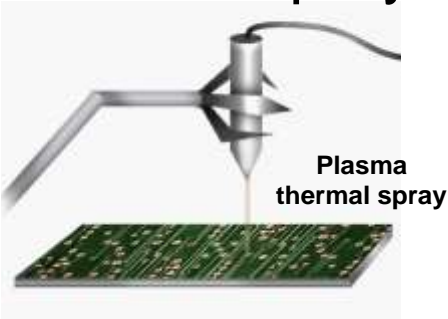
MesoScribe Technologies, Inc.
7 Flowerfield, Suite 28
St. James, NY 11780
Tel: 631.686.5710
Fax: 631.686.5709

West Coast Development & Manufacturing

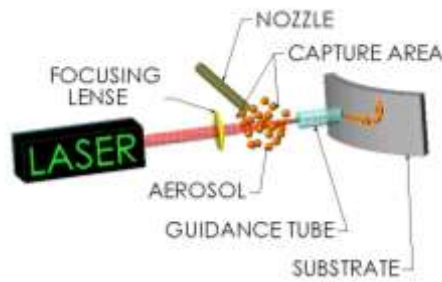
MesoScribe Technologies, Inc.
5445 Oceanus Drive #108
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Tel: 714.894.8400
Fax: 631.686.5709

Direct Write– A Platform Technology

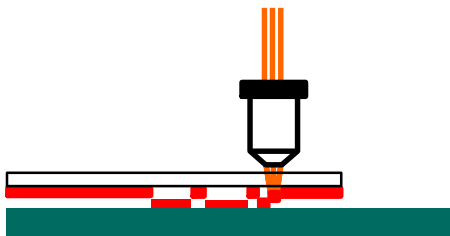
Plasma Spray



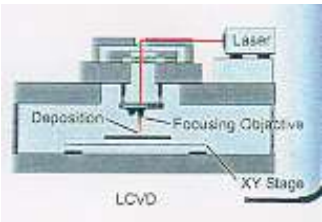
Laser Particle Guidance



MAPLE DW



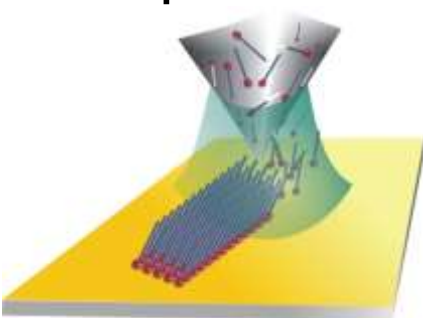
Laser CVD



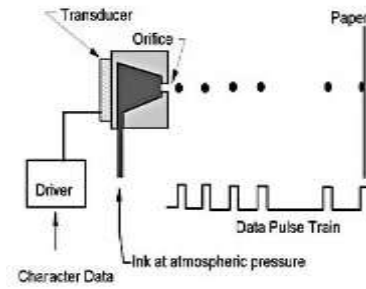
MicroPen



Dip-Pen



Ink Jet

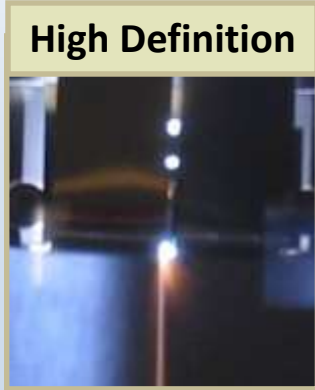
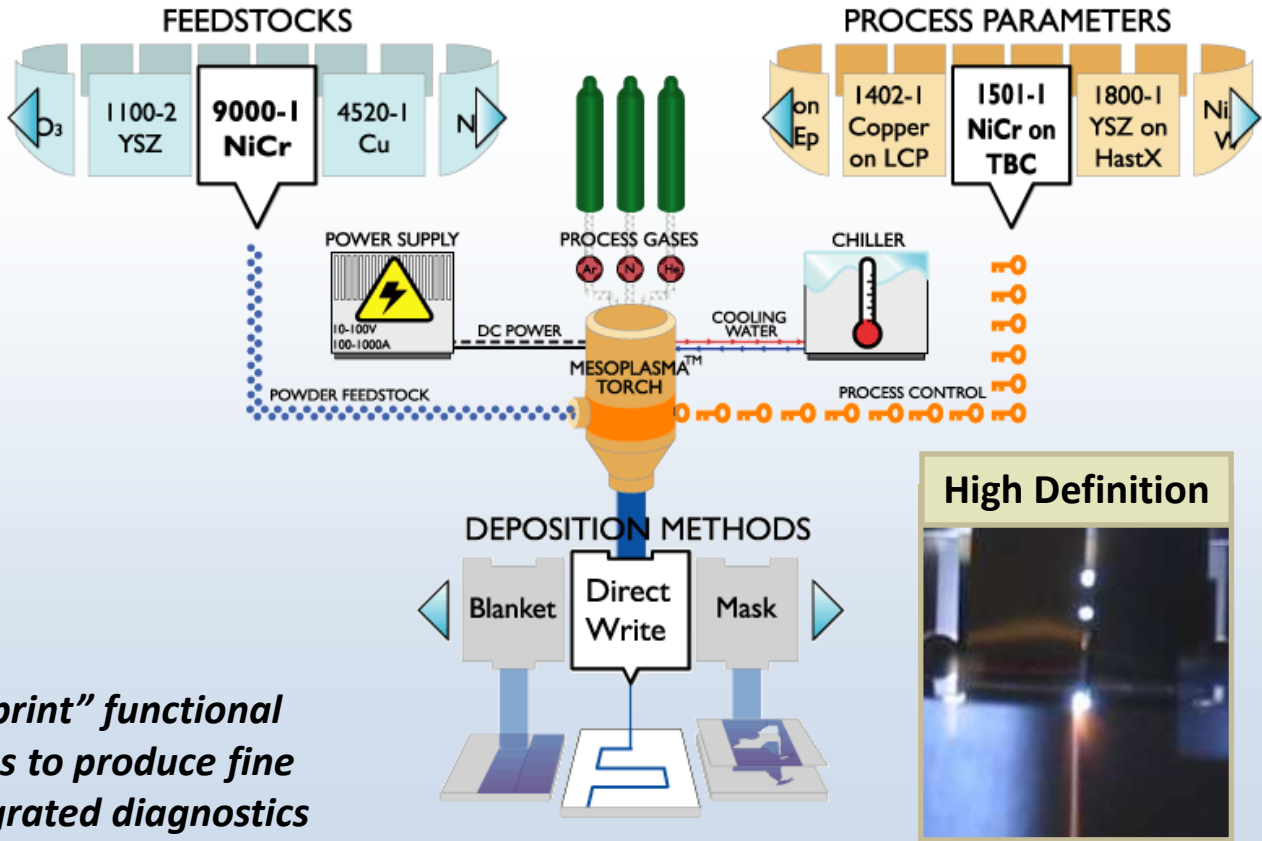


***Many Different Approaches Exist to DW Material Patterns.
Each Technique Has its Own Merits and Limitations.***

MesoPlasma™ Direct Write Processing



Platform technology used to “print” functional materials onto complex surfaces to produce fine feature sensor patterns for integrated diagnostics

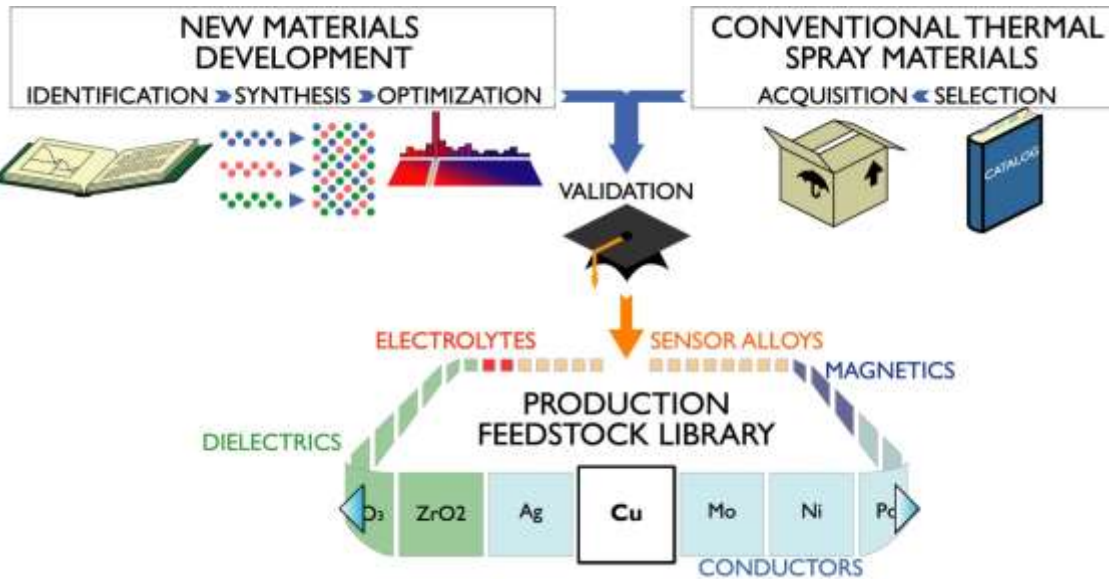


Competitive Advantages

<input type="checkbox"/> Automated for high throughput production	<input type="checkbox"/> Conformal following surface contours
<input type="checkbox"/> Repeatable between parts and batches	<input type="checkbox"/> Embeddable within coatings and composites
<input type="checkbox"/> Compatible with coatings and infrastructures	<input type="checkbox"/> Adhesive-free and high temperature tolerant

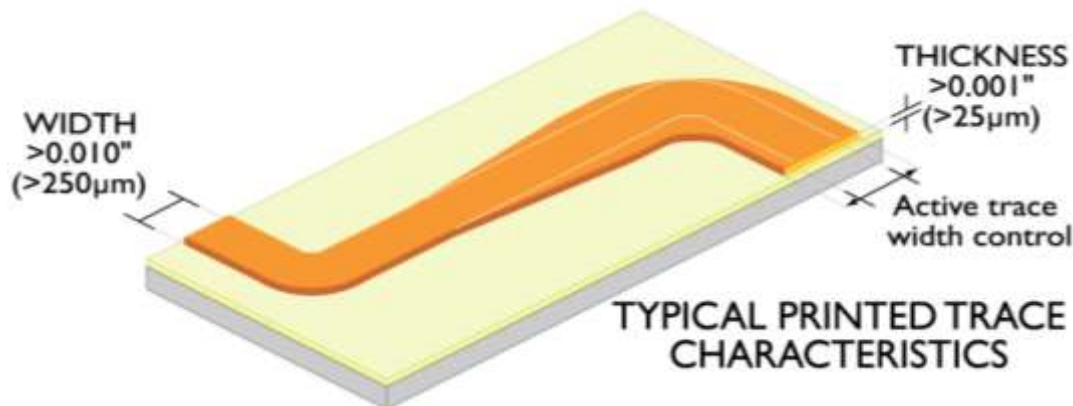
Direct Write Processing Capabilities

Materials Versatility



- ☐ **Conductors**
 - ✓ Cu, Ni, Pt, Pd, Ag
- ☐ **Sensor Alloys**
 - ✓ NiCr, NiAl, NiSi, NiCrSi, CuNi
 - ✓ NiCrAlY, FeNi, PdAg
- ☐ **Advanced Sensor Materials**
 - ✓ ITO and other ceramic TE oxides
- ☐ **Dielectrics**
 - ✓ YSZ, $MgAl_2O_4$... proprietary matls

Tailorable Trace Characteristics

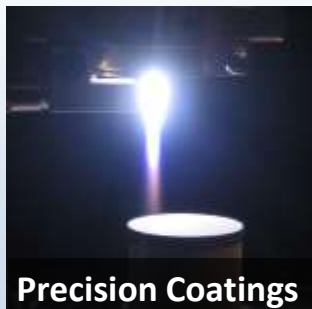
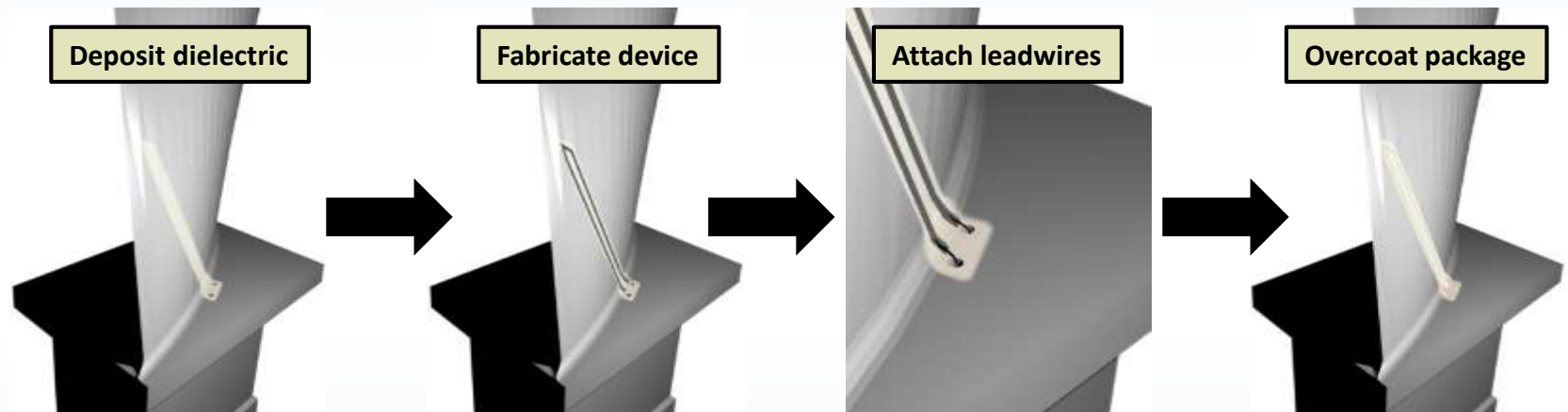


- ☐ **Dynamic trace control**
 - ✓ Trace geometry can be actively tailored for complex patterns
- ☐ **Trace width**
 - ✓ Direct Write trace $\geq 0.01"$ ($\geq 250\mu m$)
 - ✓ Laser Scribed trace $\geq 0.001"$ ($\geq 25\mu m$)
- ☐ **Trace thickness**
 - ✓ Generally $\geq 0.001"$ ($\geq 25\mu m$)

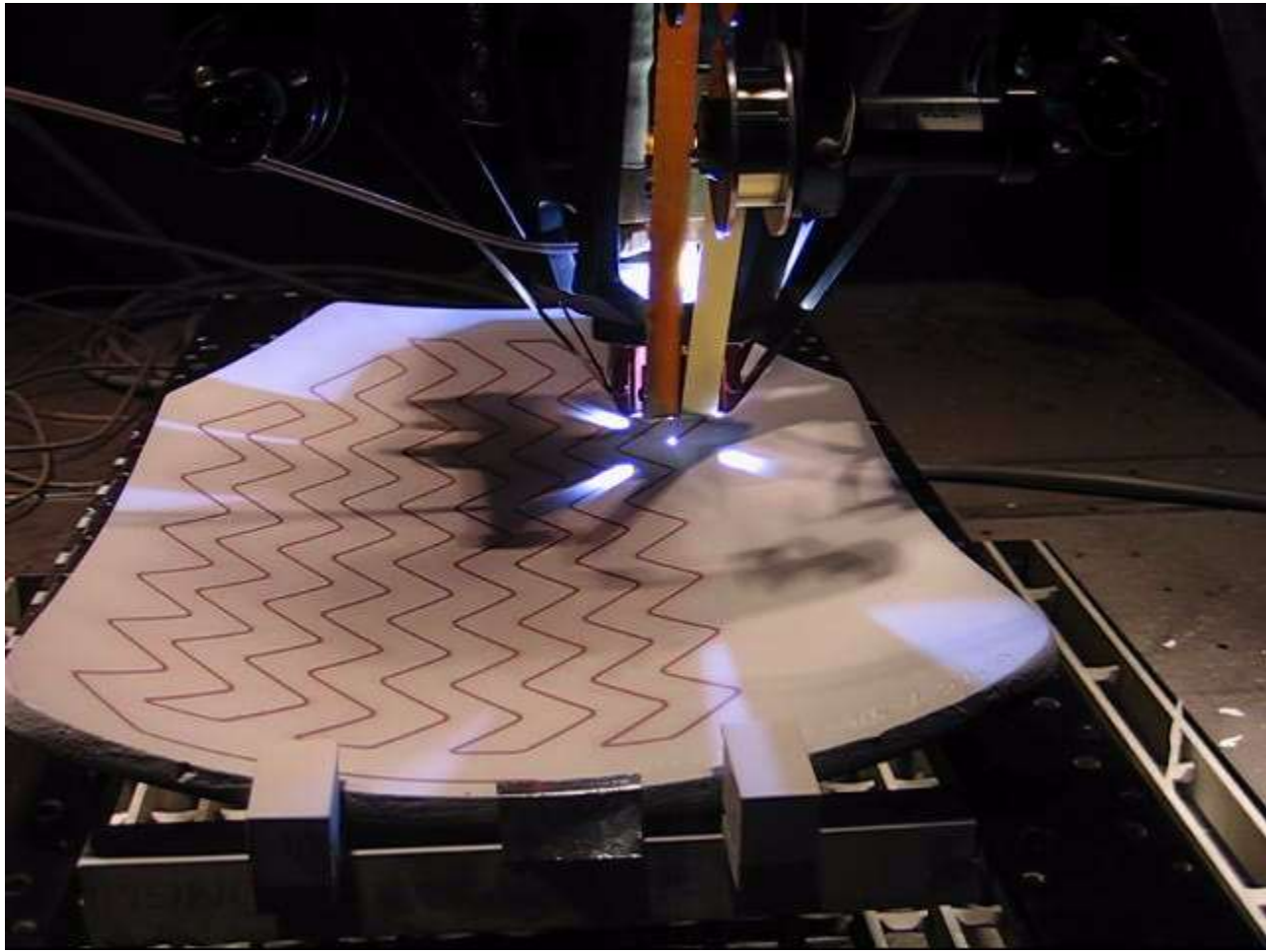
Conformal Instrumentation of Components



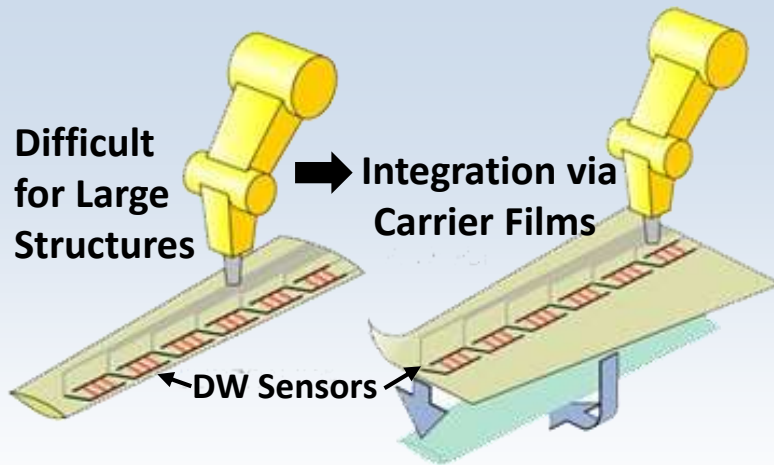
- ❑ Devices **deposited directly** onto components without masking
- ❑ Dielectrics and alloys deposited in sequence using a **single process**
- ❑ 6-axis robotic control enables **CAD driven manufacturing**
- ❑ Adhere to an **aerospace quality management system**
- ❑ **Platform technology** with unique advantages for device fabrication



Conformal Sensor Fabrication Demo



Embedded Sensors for Composite Structures

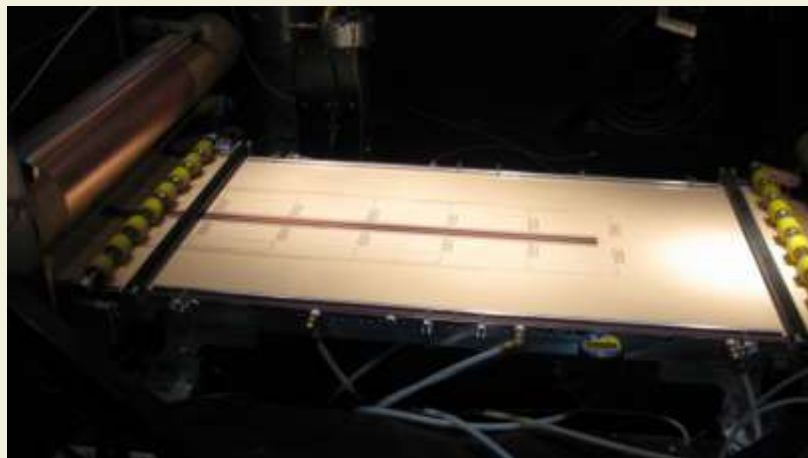


Direct Write combined with a Roll-to Roll Process

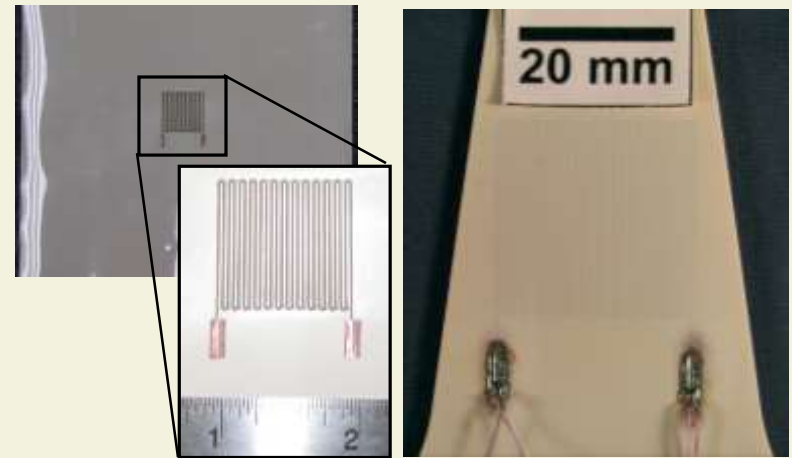
- ☐ Sensors written onto a **carrier film** using a streamline roll-to-roll process
- ☐ Instrumented carrier films **integrated** and **co-cured** within composite layups
- ☐ **No length limitation** on deposited patterns, which can span from millimeters to meters
- ☐ Films are **compatible** with composite materials

Roll-to-Roll Process for Fabrication of Instrumented Carrier Films

For Large Area Conductor Patterns...

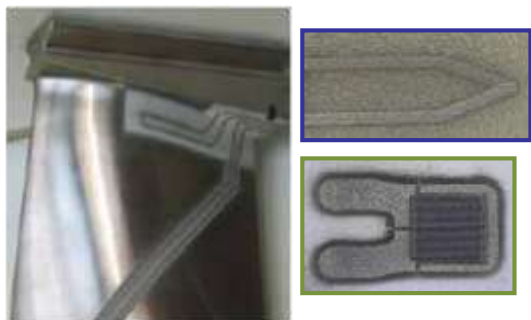


For Integrated Sensing and Diagnostics...



Commercial and Military Applications

Component Health Monitoring



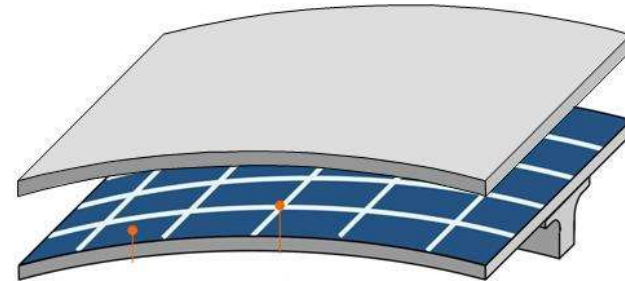
Temperature, heat flux and strain sensors for health management of gas turbine and hypersonic engines

Integrated Wiring



Copper traces for power management and signal routing for surface mount and embedded electronics

Structural-Energy Storage



Capacitor arrays and control circuits for power storage within UAV structures

Damage Detection



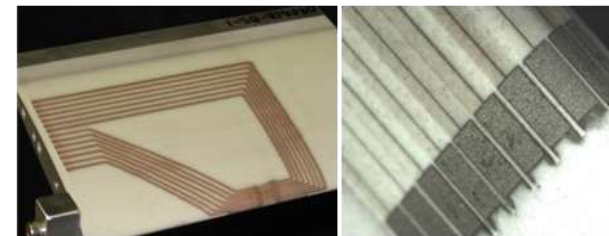
Sensor patterns for detecting foreign object damage and cracking within composite structures

Signals Intelligence & Communication



Multi-band and conformal antennas for integration within aerostructures

Active Flight Control



Stagnation sensors and strain gages for active aeroelastic control and structural health monitoring

Application: Harsh Environment Sensing

DEMAND

Robust sensors for component health management in extreme operating environments

Component Instrumentation



Sensor Layout



DW Fabrication



Integrated Sensing



Robust Sensor Design and Packaging



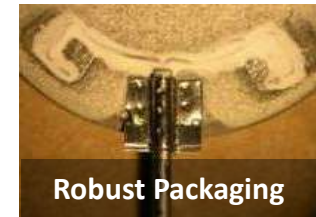
Strain Gages



Thermocouples



Heat Flux Sensors



Robust Packaging

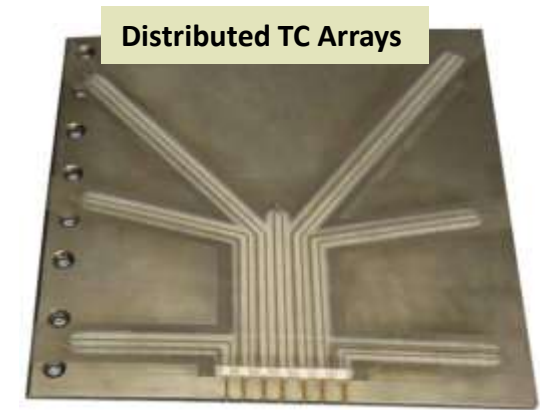
ENABLE

Smart Components with real-time access to operational status, optimized performance, and enhanced reliability and availability

- ☐ Prognostic support
 - ➔ Unplanned shutdown prevention
 - ➔ Higher availability
- ☐ Measurement of component states
 - ➔ Reduced uncertainty, margins
 - ➔ Higher temperature operation
 - ➔ Higher efficiency, reduced emissions

Direct Write Thermocouples

- Direct Write temperature sensors provide an accurate measure of **component temperature**
- Nickel alloy TCs meet NIST standards for straightforward integration and **cost-effective implementation**
- Pt-Pd TCs demonstrate superior oxidation resistance and provide a solution for **long-term health monitoring**

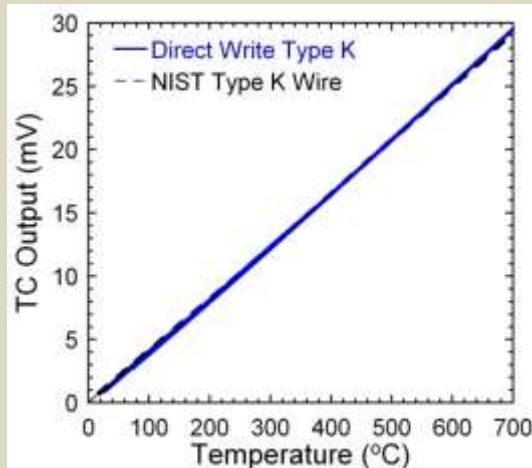


Type K Thermocouples

High sensitivity for reliable temperature measurement

NiCr vs. NiAl

Meets NIST Standard within $\pm 1.5\%$

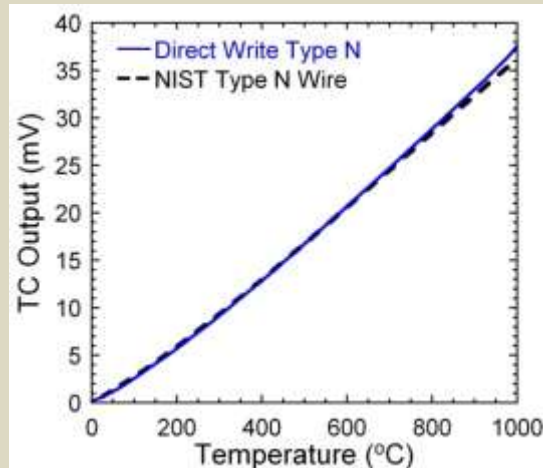


Type N Thermocouples

High sensitivity and improved oxidation resistance over Type K

NiCrSiI vs. NiSiI

Meets NIST Standard within $\pm 2\%$

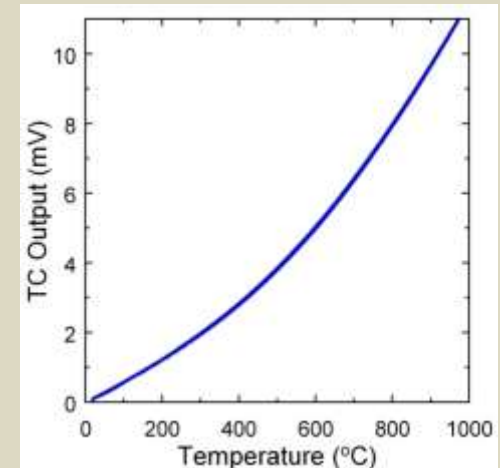


Precious Metal Thermocouples

Superior durability and oxidation resistance

Pt vs. Pd

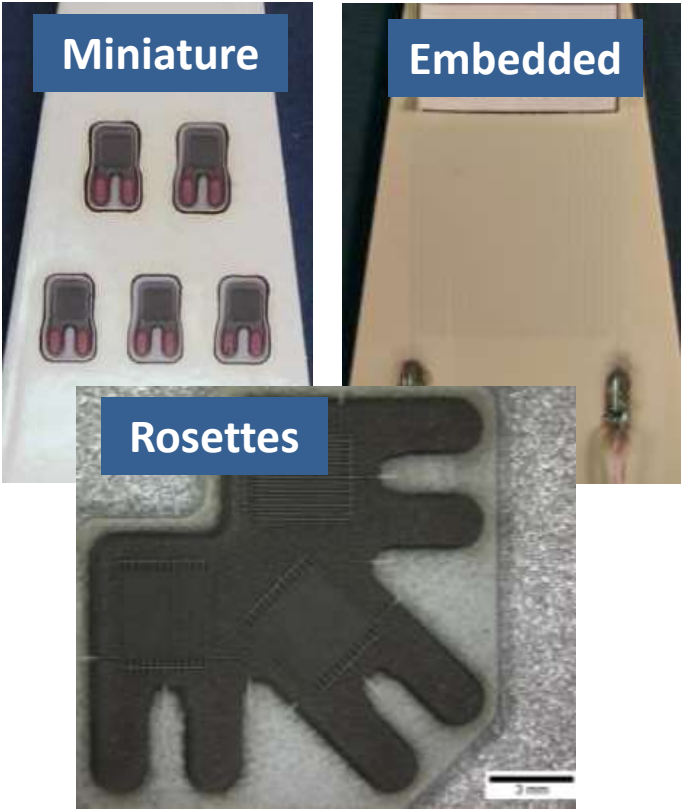
Customized Calibration



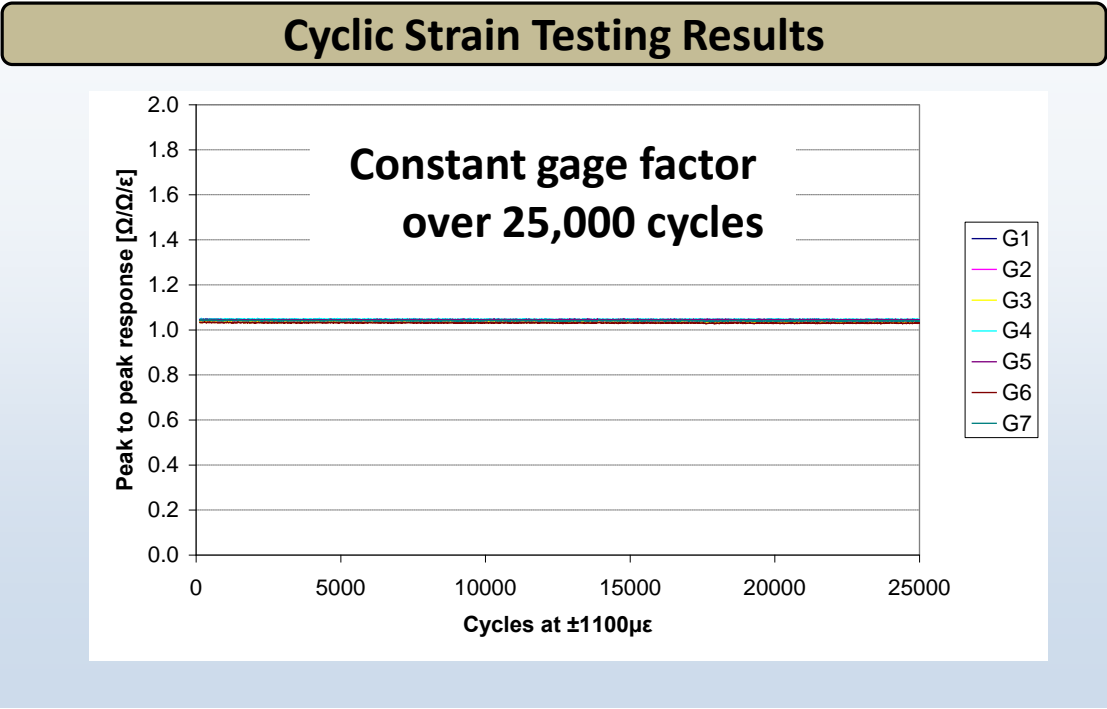
Direct Write Strain Gages

For **structural state sensing**, Mesoplasma™ Direct Write Gages are well-suited for monitoring of:

- ❑ Wetted surfaces, due to their low profile, robustness, and conformability
- ❑ Hot structures, such as nozzles and nacelles
- ❑ Composite structures, including aerospace (fixed wing and rotorcraft) and shipboard



Sensor Specifications	
Resistance	50Ω-1000+Ω (Customizable)
Gage factor	1.0-3.5 (Nickel-based) >3.5 (Precious Metals/ Ceramics)
Thermal output	As low as 65με/°F (117με/°C)
Temperature limit	Beyond 1500°F (816°C)
Total thickness	0.002-0.006" (50-150μm)



Diagnostic Heat Flux Sensors

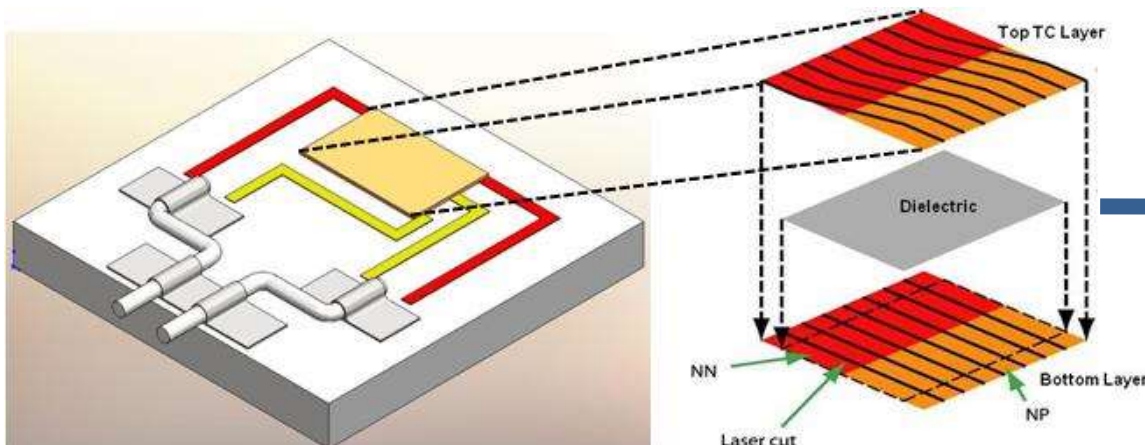
The Challenge

Whereas **temperature** is a thermodynamic property describing the state of a system, **heat flux** is a transport property which requires heat to be transferred through a device for quantification

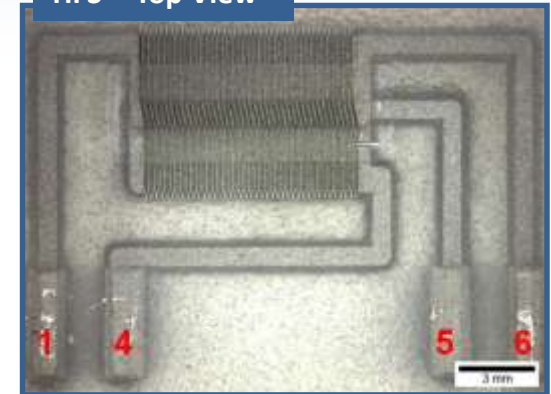
The Solution

Use Direct Write to fabricate a multilayer thermopile

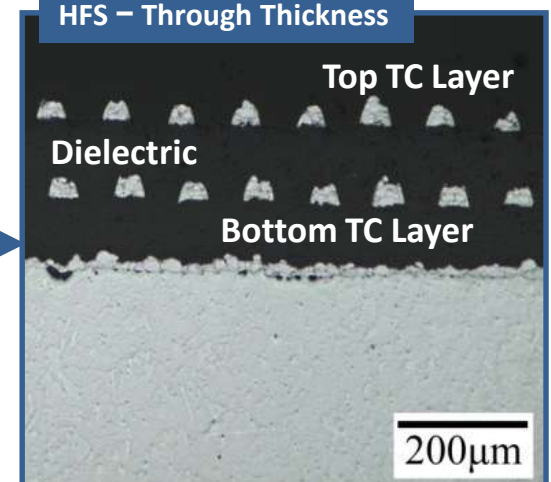
- Lower layer of 'N' parallel thermocouples fabricated from thermoelectric alloys that meet the application requirements
- Intermediate dielectric encapsulates the lower TC junctions to establish the required through-thickness thermal gradient, ΔT
- Upper layer of parallel thermocouples indexed to produce a single thermopile coil which generates an output voltage, ΔV



HFS – Top View



HFS – Through Thickness

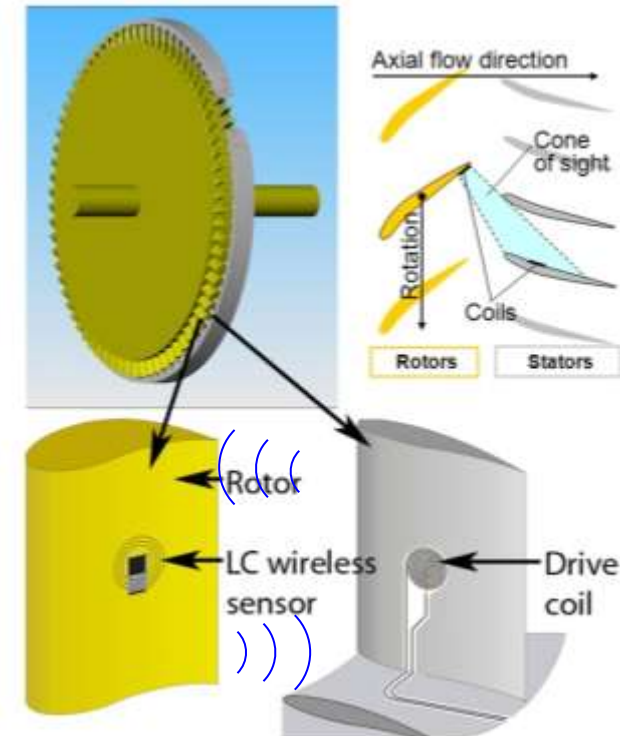
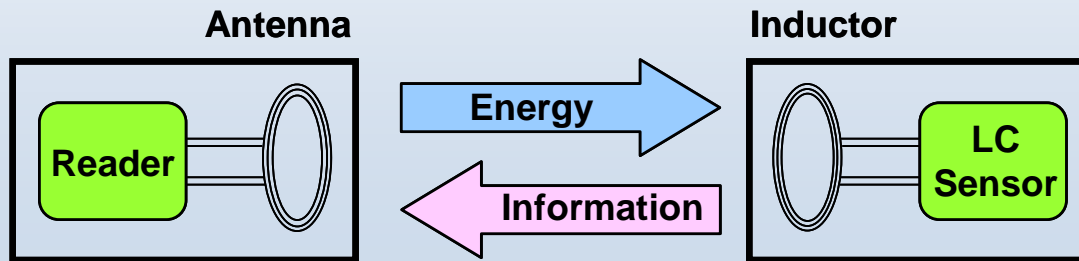


Passive Wireless Sensing for Industrial Gas Turbines

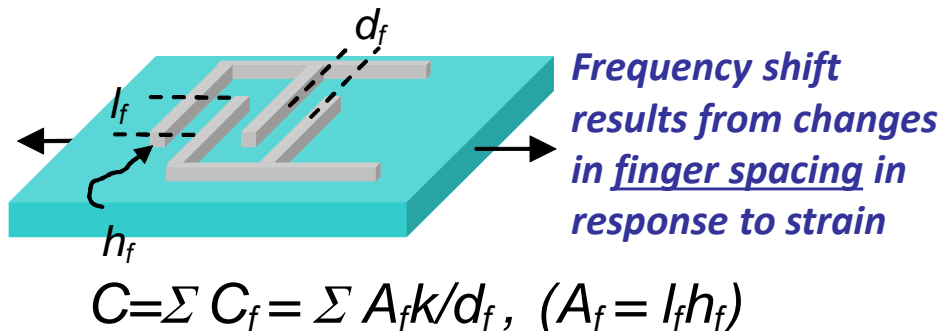
DoE Phase I SBIR Program Objective

Demonstrate passive wireless sensors for measuring temperature and strain on rotating turbine components

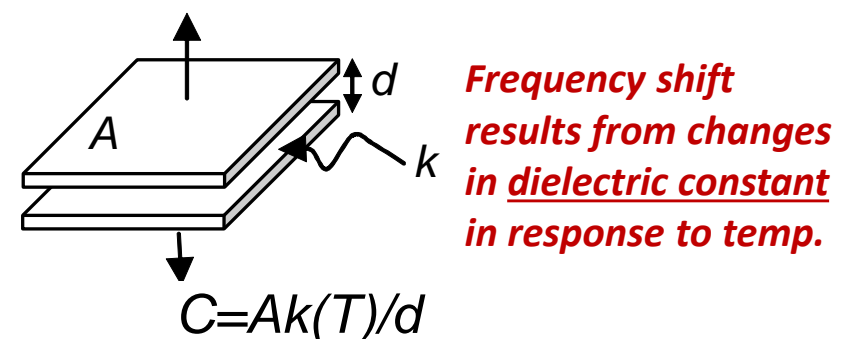
- ❑ Based on inductive coupling between a remote reader and LC sensor circuit with a **strain** or **temperature** dependent capacitance
- ❑ Resonant frequency shifts due to impedance variations which can be correlated to physical quantities (T and ϵ)



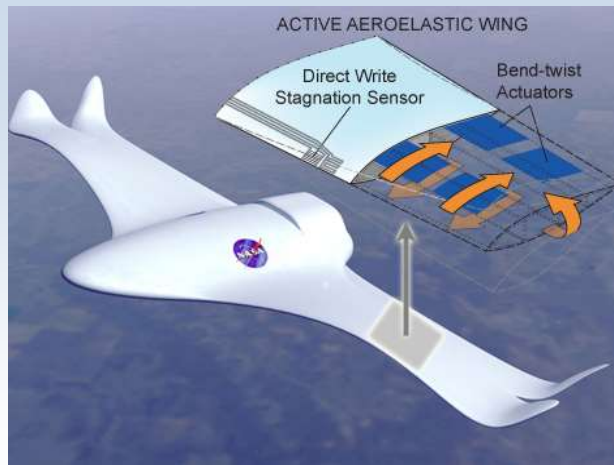
Capacitor Design for Strain Monitoring



Capacitor Design for Temperature Sensing



Application: Multifunctional Structures



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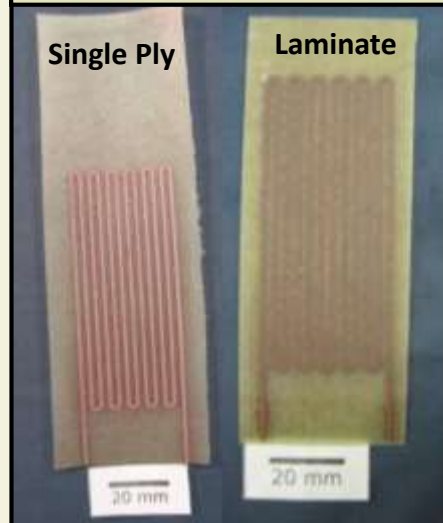
- ☐ Improved performance, maneuverability and survivability
- ☐ Functional capabilities within large aerostructures
 - Health and condition monitoring
 - Damage detection
 - Active aeroelastic control
- ☐ Simultaneously optimize performance and efficiency

Distributed Sensing Networks

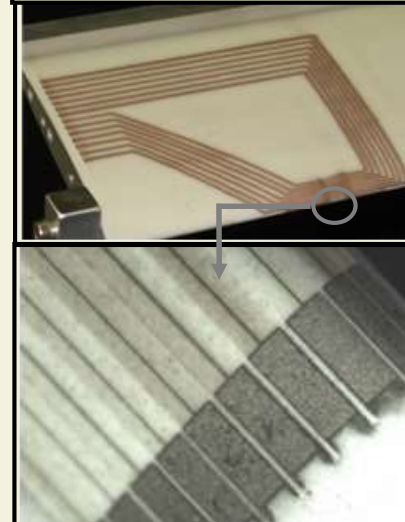
Structural Energy Storage



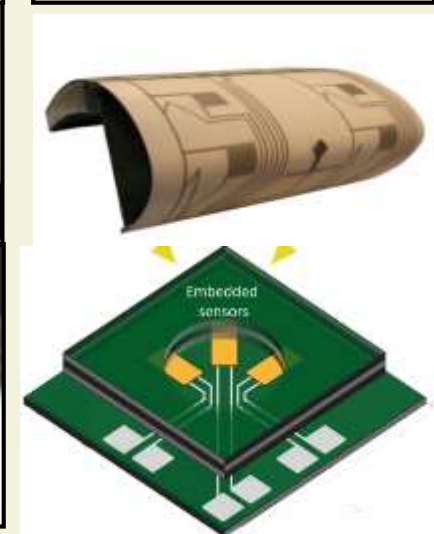
Embedded Damage Sensing



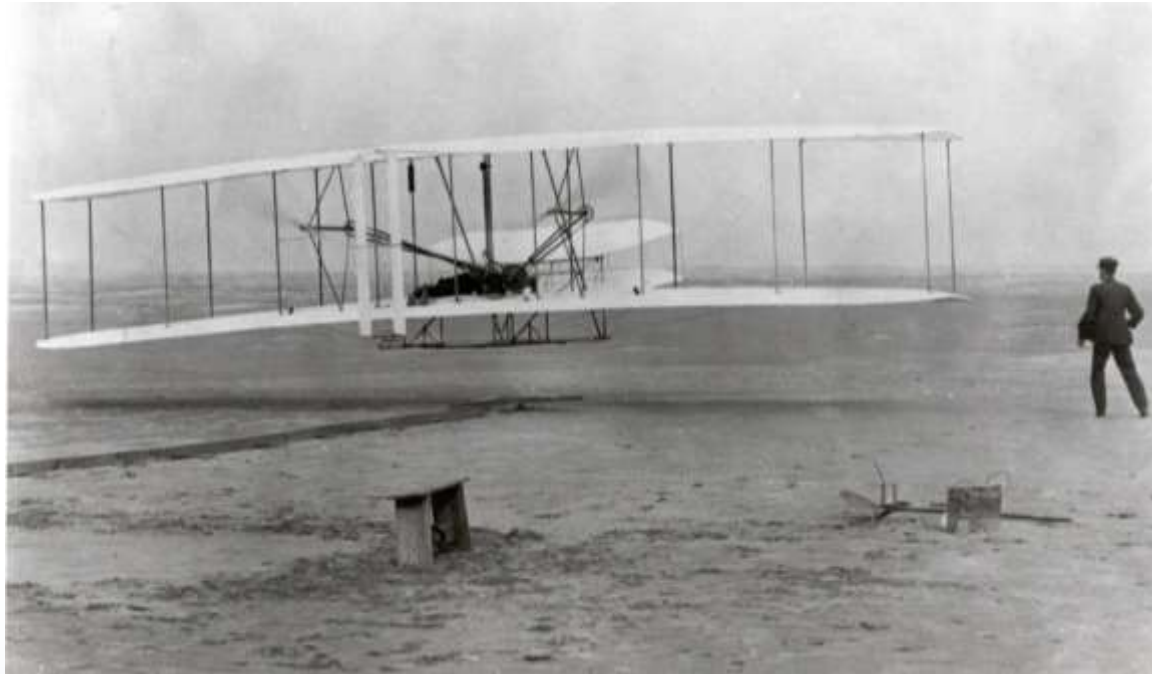
Aerodynamic Sensing



Distributed Sensing Arrays



Direct Write Sensors are Flying!



DW technology – from idea to airplane in under 3 years!

MesoScribe provides Direct Write sensors to a major aircraft manufacturer for use on a production aircraft currently undergoing flight testing.

- ☐ Implemented an aerospace quality management system (AS9003)
- ☐ FAA approved manufacturing process
- ☐ Production volume manufacturing

Application: Integrated Wiring



DEMAND

Integrated power management and signal transmission networks routed directly onto, or embedded within structural components to reduce installation costs and weight while improving reliability.

Embedded Wiring Networks

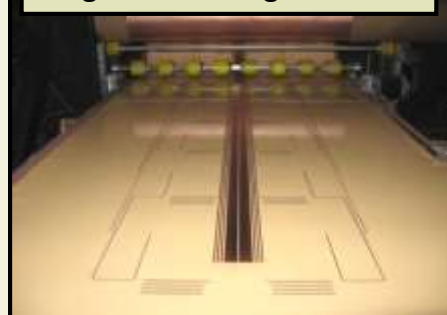
- Sensors written onto a **thin flexible films** using a streamlined **roll-to-roll process**
- Instrumented carrier films **integrated** and **co-cured** with composite layups
- Traces routed over **large areas** (>1m) with **exceptional durability** and 2X bulk resistivity

Shielded Signal Routing Networks

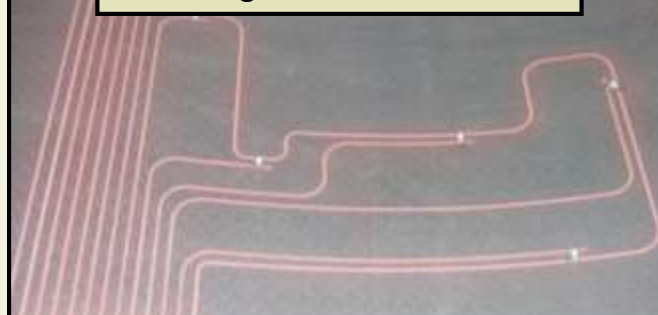
- Dielectrics **deposited by Direct Write** employed for electrical insulation
- Wire traces encompassed within a **metallic jacket** for shielding purposes
- Conductors prescribed to match AWG wiring standards

Direct Write Wiring Networks

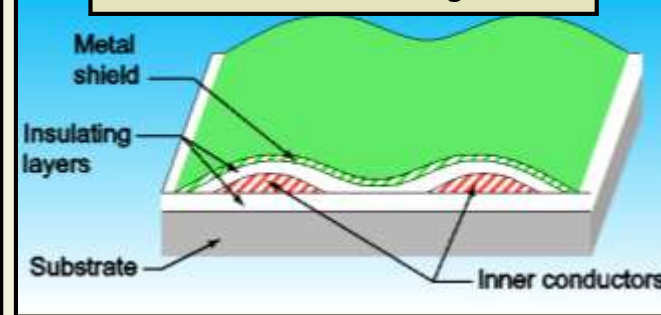
Large Area Wiring Networks



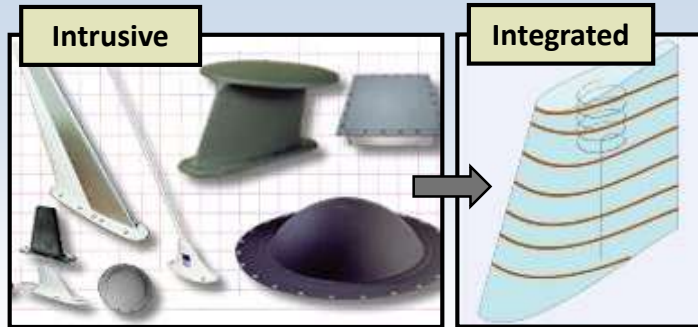
Patterning of Flexible Conductors



Shielded Conductor Configurations



Conformal and Integrated Antennas



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Replace bulky antennas that disrupt airflow with low-profile antenna structures that can be made conformal and/or structurally integrated within the air vehicle

Conformal Load Bearing Antenna Structures



737 Wing-to-Body Fairing

Flexible, Large Area Antennas



Printed Conformal Antennas



Integrated VHF/GPS for Dakota UAV Platform

ENABLE

- ☑ Large area antenna fabrication
- ☑ Low-profile, conformal patterns for aerodynamic surfaces
- ☑ Integrated antennas for composite structures, with emphasis on UAVs

SAW Sensor Fabrication via Direct Write

NASA Phase II SBIR Program

Composite Structure Monitoring using Direct Write Sensors

Start Date: 06/01/2011 (Contract No. NNX11CB86C)

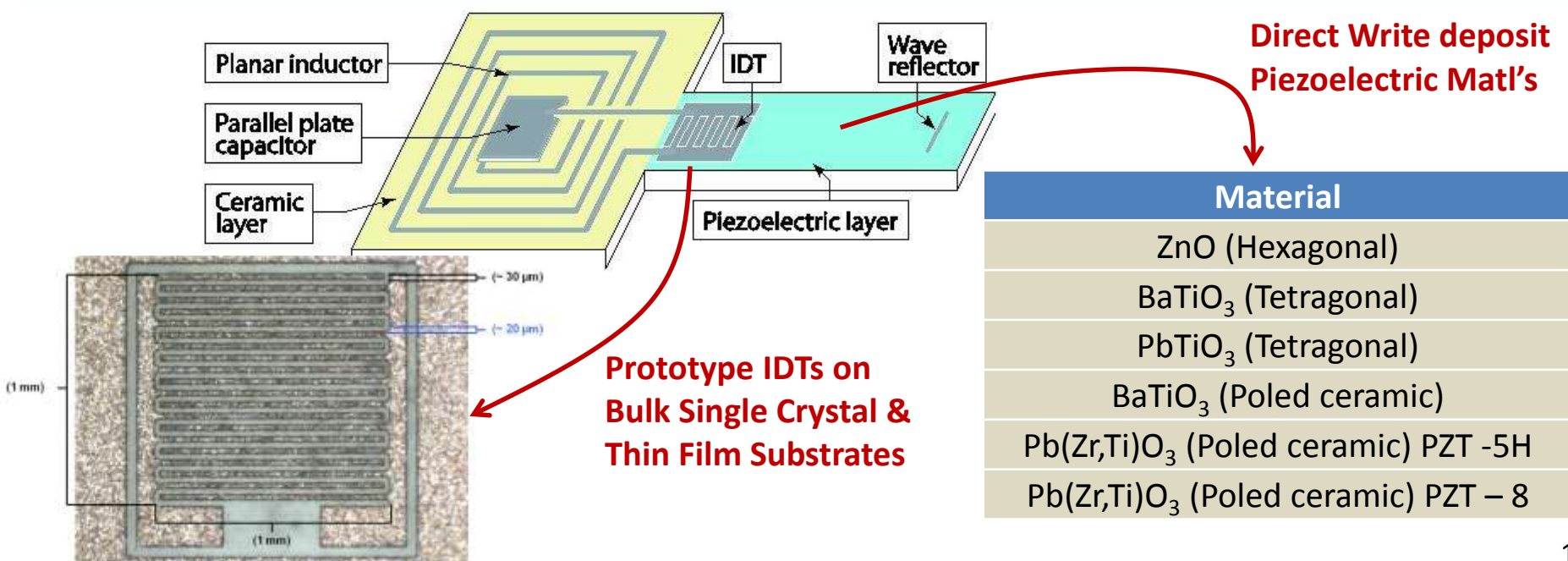
Period of Performance: 24 Months

Principle Investigator: William Smith – MesoScribe Technologies

COTR: William (Cy) Wilson– NASA LARC

Goal: Demonstrate and mature Direct Write as a general processing tool for fabricating sensors (passive & active) for NASA health monitoring applications

Technical Objectives for Passive Wireless Sensor Development





MesoPlasma™ Direct Write Technology

Conformal Fabrication of Sensors and Antennas

- ❑ Proven process for fabricating structurally integrated electronics for advanced sensing and communications
- ❑ Prototype fabrication and product manufacturing
 - Cost-effective implementation
 - Adheres to aerospace quality management system
 - Production volume manufacturing for aerospace applications

For further information, please visit our demo table!



Contact Information

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