

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [IG DEP Requirement for Wireless Medical BAN to Apply for ECoG-based Brain-Machine Interface]

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Re: []

Abstract: [A important use case of dependable body area network(WBAN) for implanted devices is introduced to perform reliable and massive data for ECoG-based Brain machine interface to require amendment for IEEE802.15.6 wireless medical body area network.]

Purpose: [information]

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Requirement for Wireless Medical BAN to Apply for ECoG-based Brain-Machine Interface

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Outline

■ ECoG-BMI system

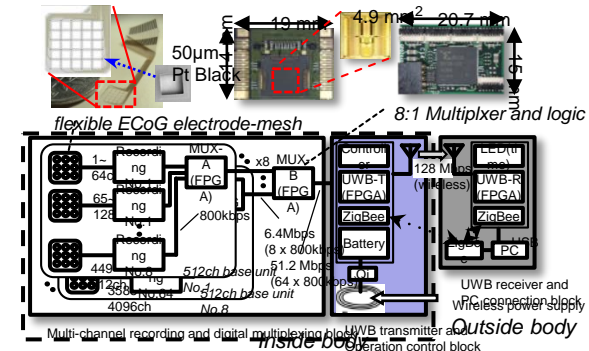
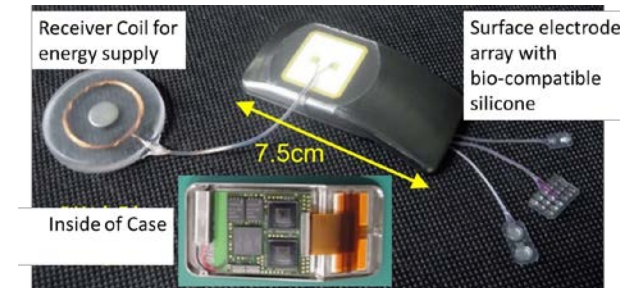
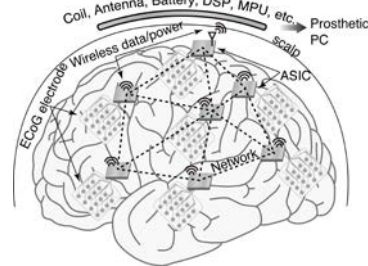
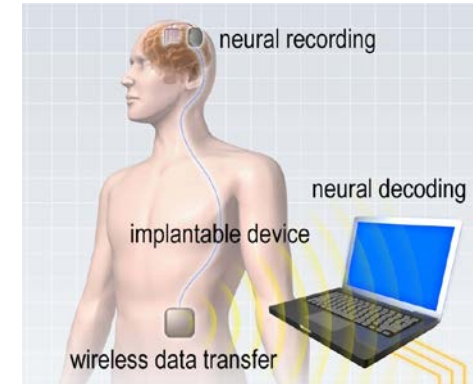
■ 1st Generation **128ch system**: Clinical ECoG-BMI system
 → Clinical test in 2020

■ 2nd Generation **4096ch system**
 → Next generation system

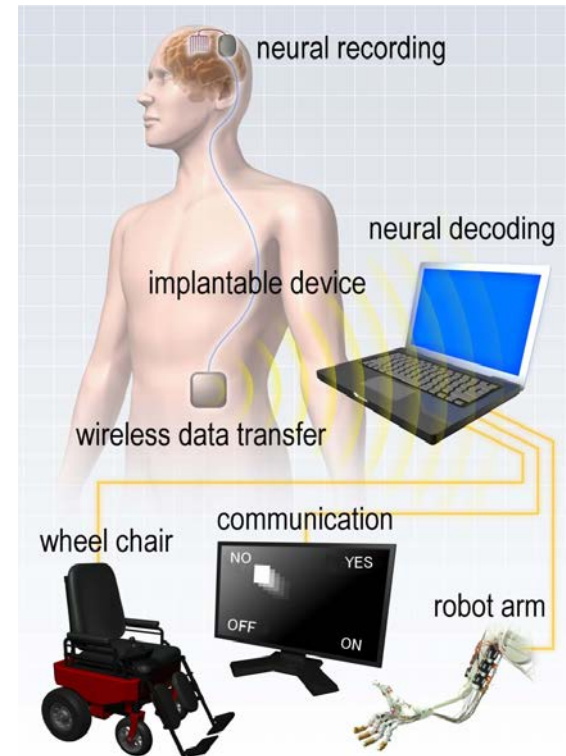
- Flexible electrode technology
- UWB wireless technology

■ BMI (system evaluation)

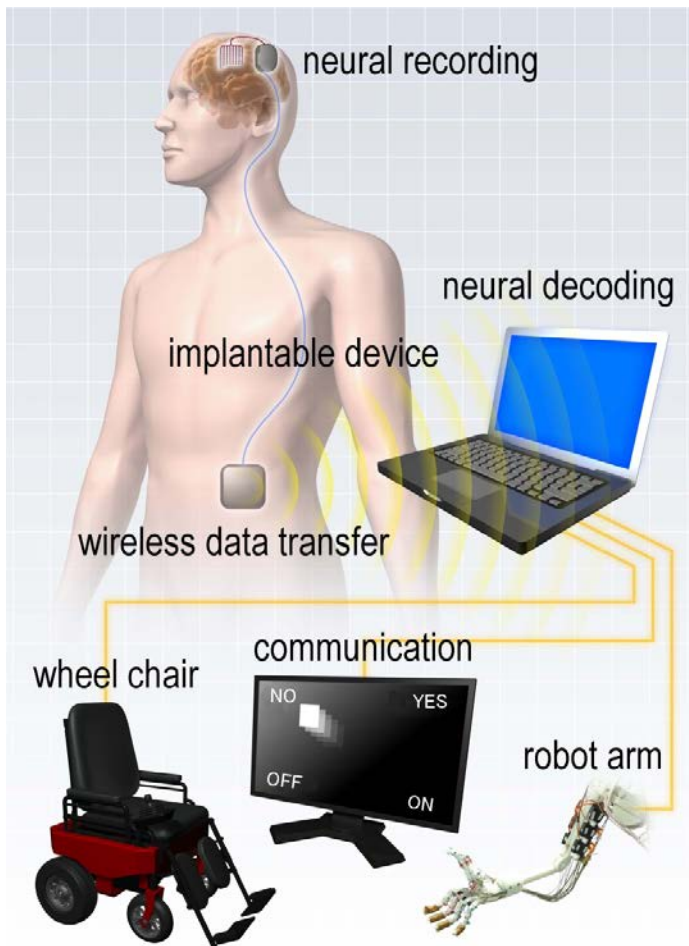
- Real-time decoding
- Robotic arm control and cortical adaptation



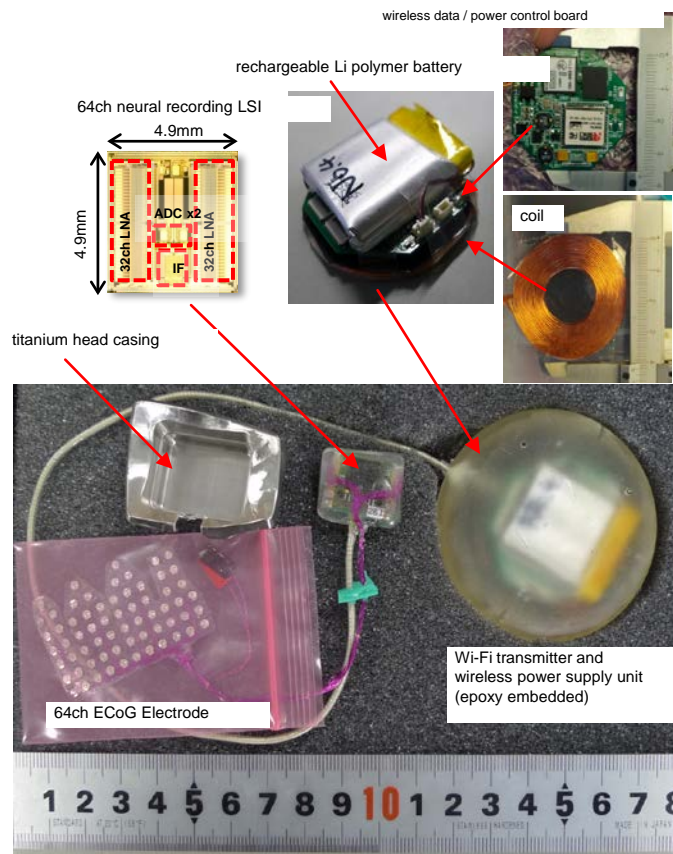
1st Generation (128ch ECoG-BMI system)



A fully implantable wireless BMI system



Pre-clinical test in 2017
 ⇒ Clinical test in 2018



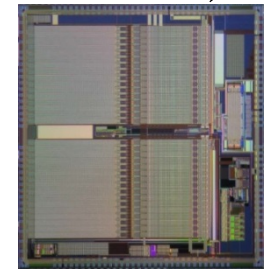
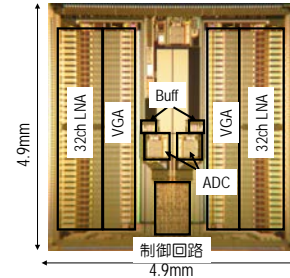
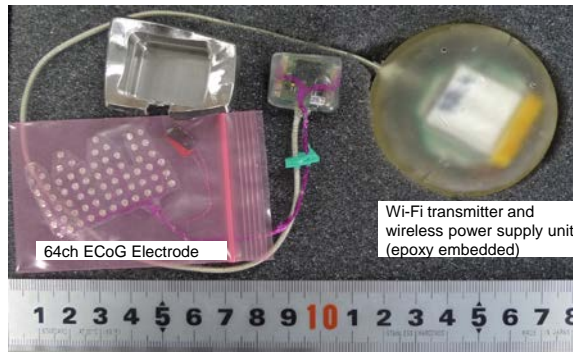
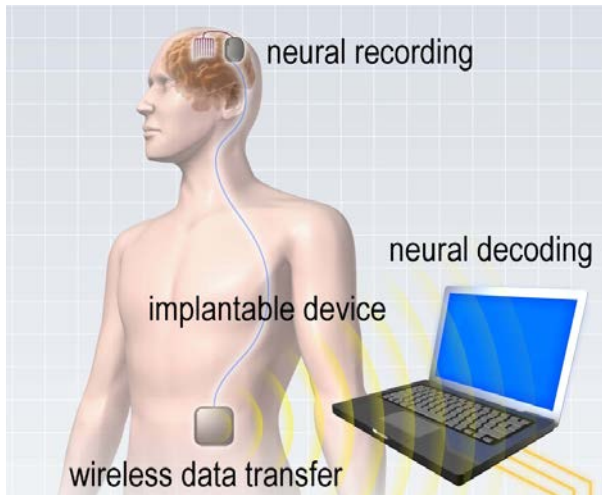
Prototype 64/128ch system
 six months in a monkey (2013)

1st Generation 128ch system (Improvement for clinical use)

■ Abdomen unit

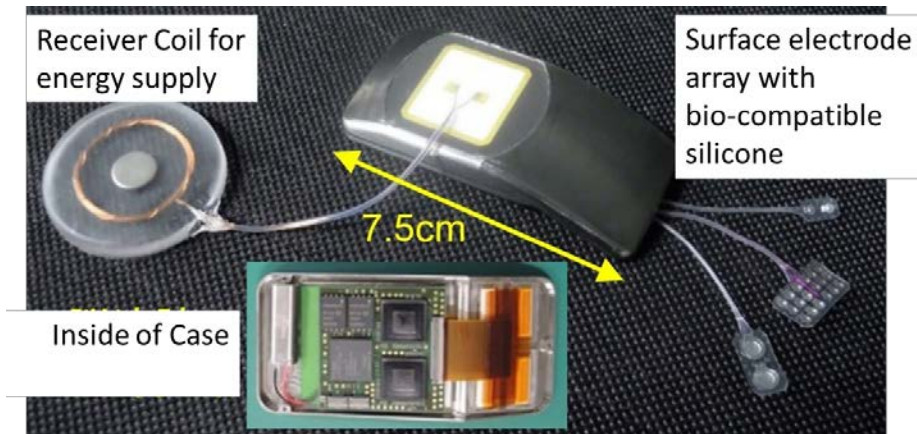
→ Integrated into head unit

Smaller system can decrease various risks.



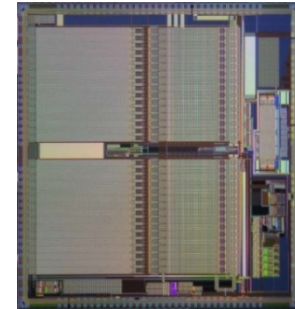
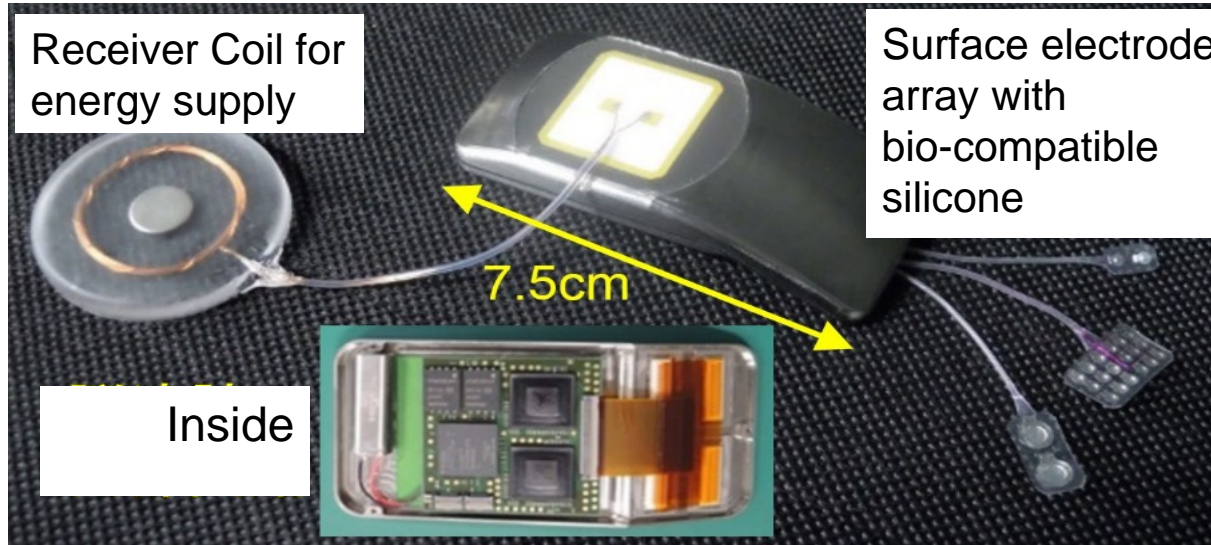
TSMC CMOS
0.25 μ m
(7.1mm × 7.3mm)

- LSI improvement
- Lower noise, safety, etc.



Current version:
Casing, non-touch energy supply

1st Generation 128ch system (Improvement for clinical use)



TSMC CMOS 0.25 μ m
(7.1mm \times 7.3mm)

-32ch x 4chips

-Noise (input) 3 μ Vpp

-Capable of High- γ
band recording

Wireless transmitter (2.4 GHz ISM Band) ~
1.9Mbps

- GLP test (bio-compatibility)
- Implant test (animal)



2nd Generation (4096ch ECoG-BMI system)

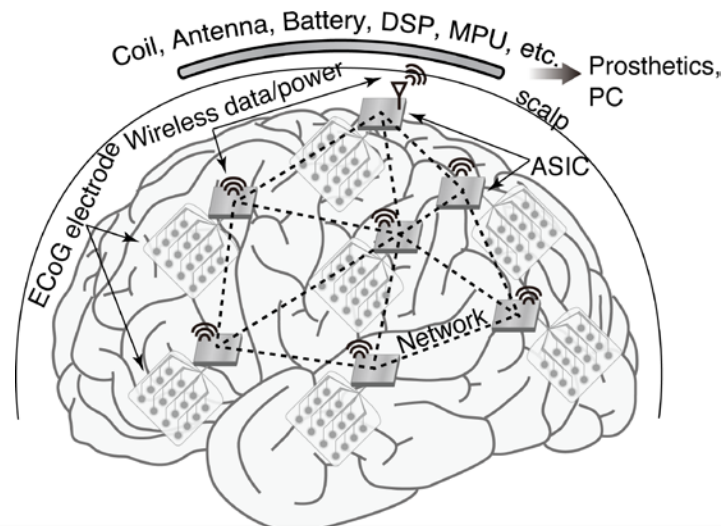
Next generation multi-channel BMI system more than 4,000 channels

For more accurate estimation of movement intentions

- a large number of recording channels
- recording at several regions simultaneously

Our target

implantable, distributed, and wireless



Issue of multi-channel system: volume of data

ex. ECoG, 1kS/s, 12bit-ADC

⇒ ~1Mbps@100ch, **~100Mbps@10,000ch**

Improvement for next generation (128ch-> 4096ch)

Issues to be solved

(1): High density electrode array

Silicone + Pt array

→ Parylene-C + Pt (or Au)

(2): LSI (amplifier + ADC)

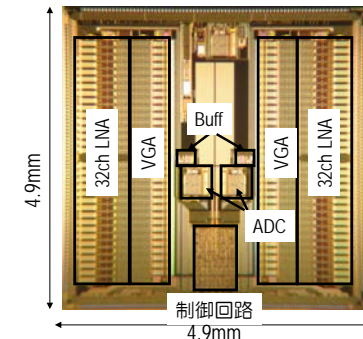
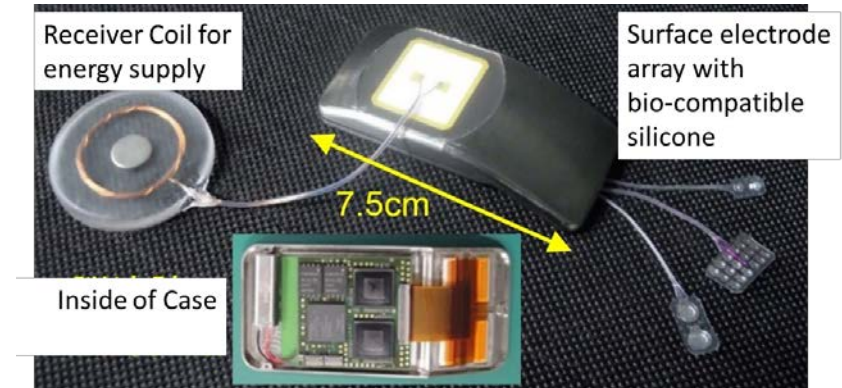
32ch x 4 chips

→ 64ch x 64chips

(3): Wireless transmitting

ISM (1.9Mbps)

→ UWB(128Mbps)

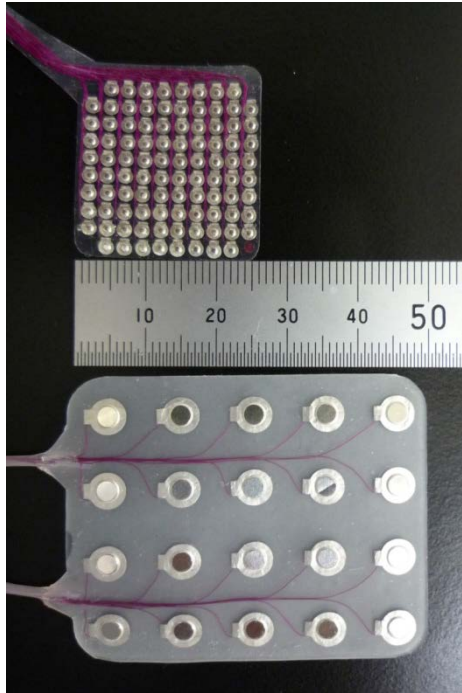


2nd Generation (4096ch ECoG-BMI system)

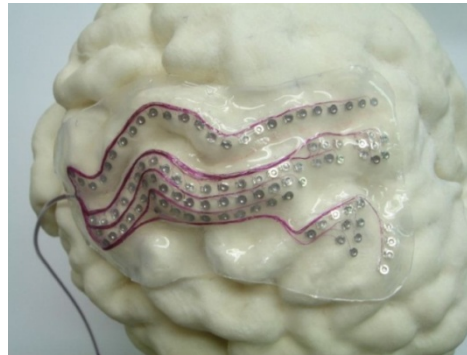
Flexible electrode technology

Electrode Array

(Safety, High density, Stability)



Up: **High Density**
(IED: 2.5mm)
Down: Clinical



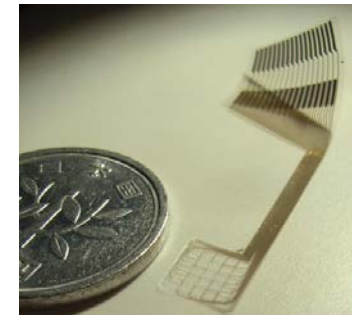
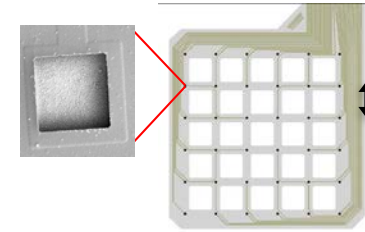
3D-shape

Individual MRI Data
1st Generation



3D-double surface

for intra-sulcus



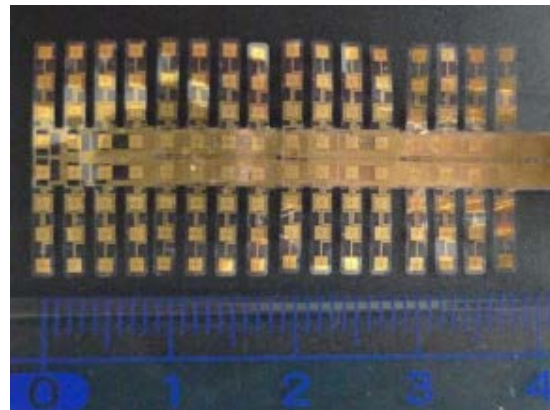
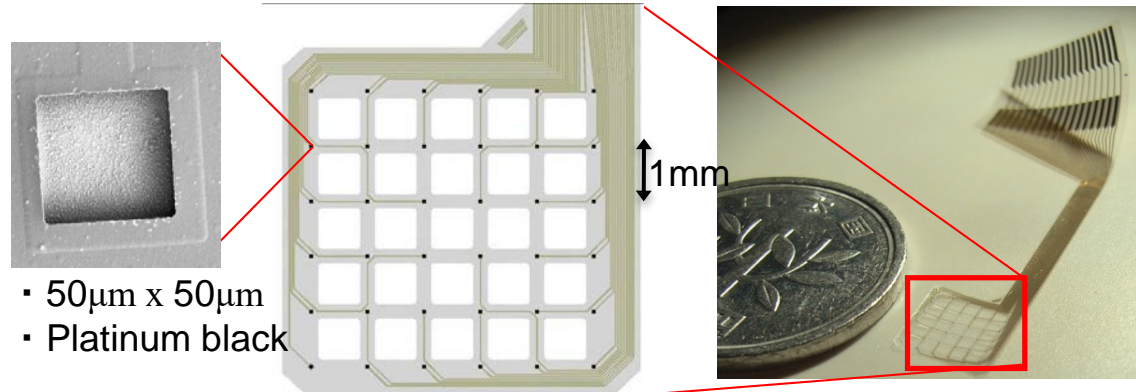
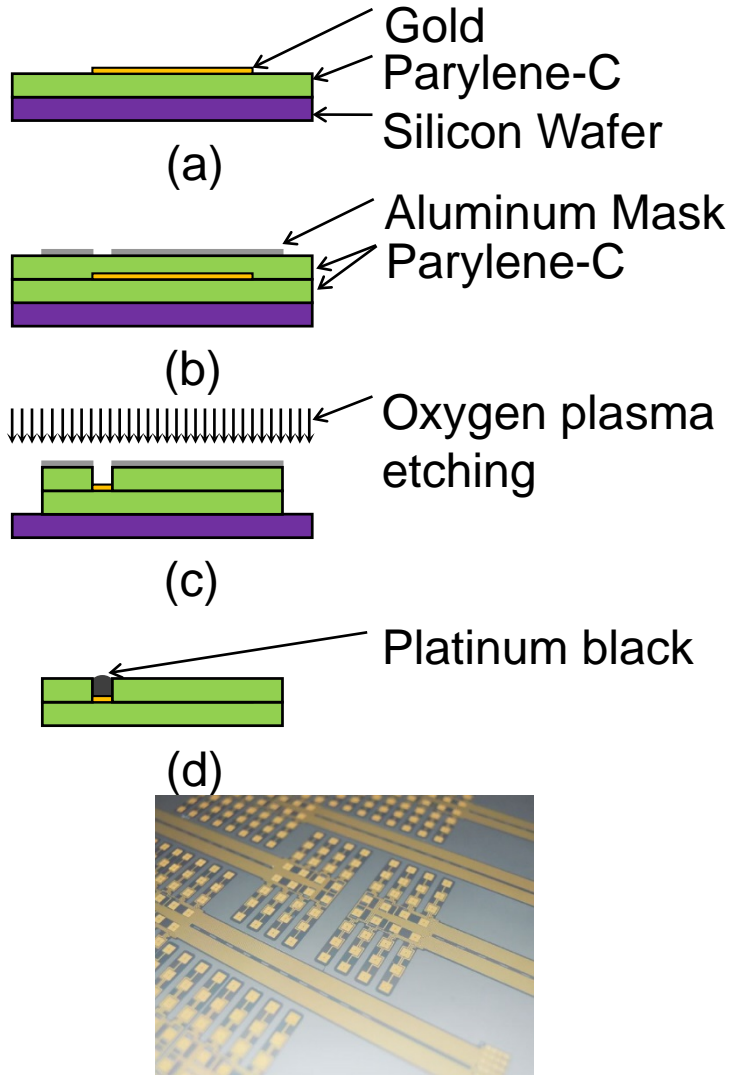
Flexible electrode array

- Parylene-C、 High Density: IED 50μm
- Relationship between intracortical and ECOG signal

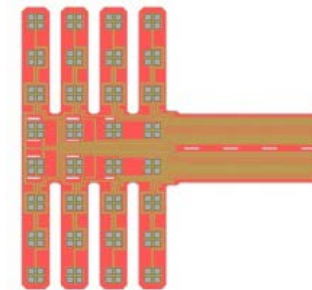
2nd Generation

(Hirata M, IEICE Trans Commun, 2011)

Flexible Electrode array for ECoG



Toda, Neuroimage(2011)



Monkey128ch

- > 2.5 years

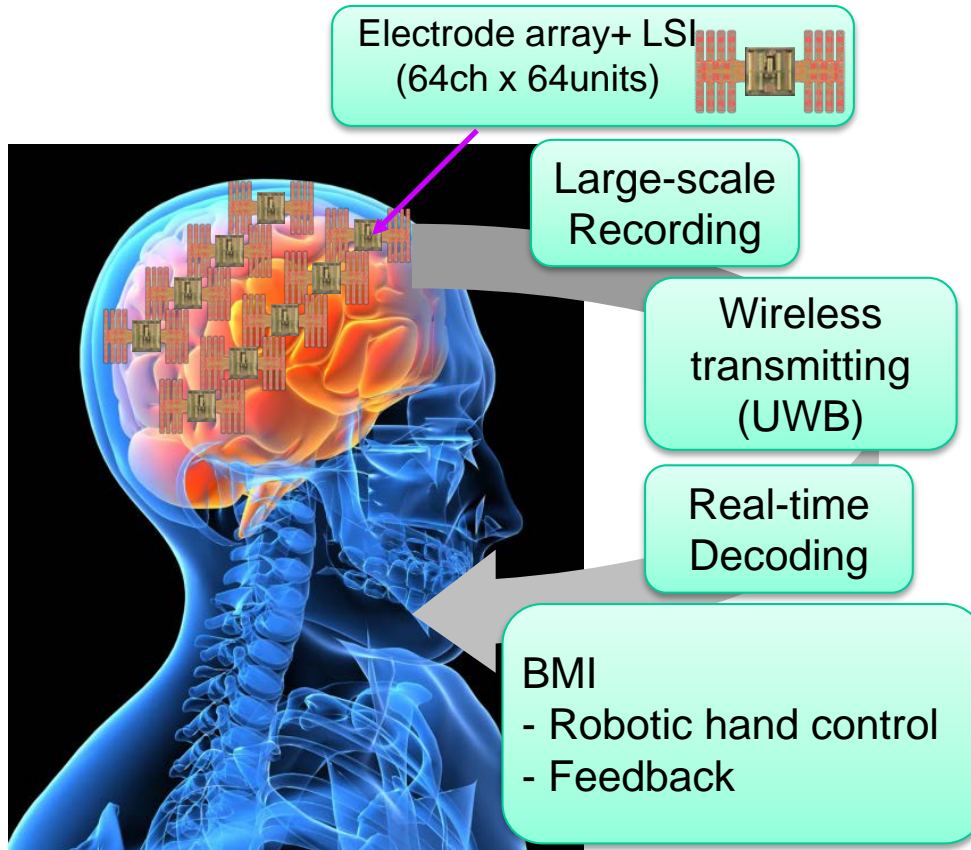
- into sulcus

(Hasegawa Lab,
Niigata Univ.)

2nd Generation (4096ch ECoG-BMI system)

Wireless technology
⇒ UWB (Ultra-Wide
Band)

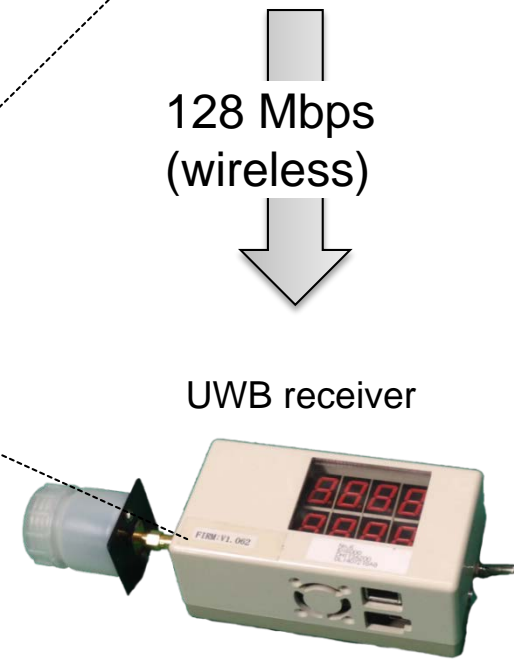
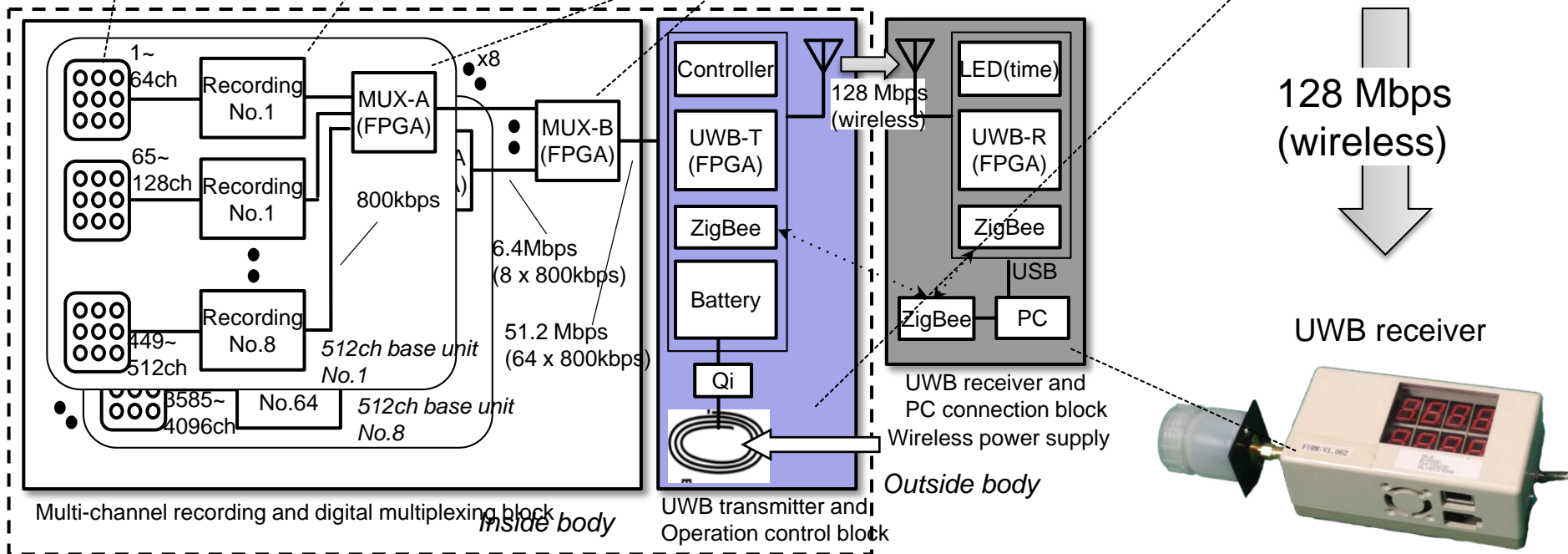
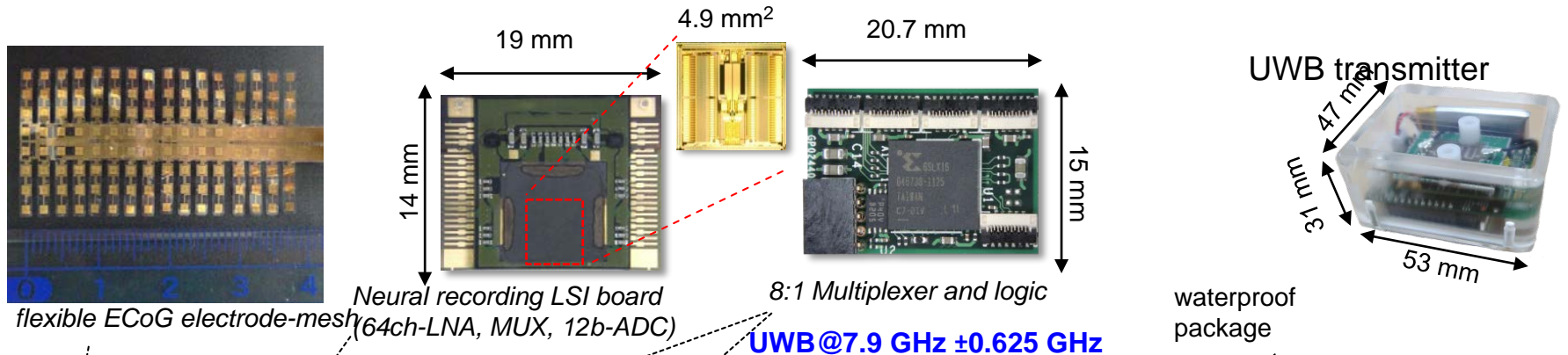
Super multi-channel system using UWB(4096ch~)



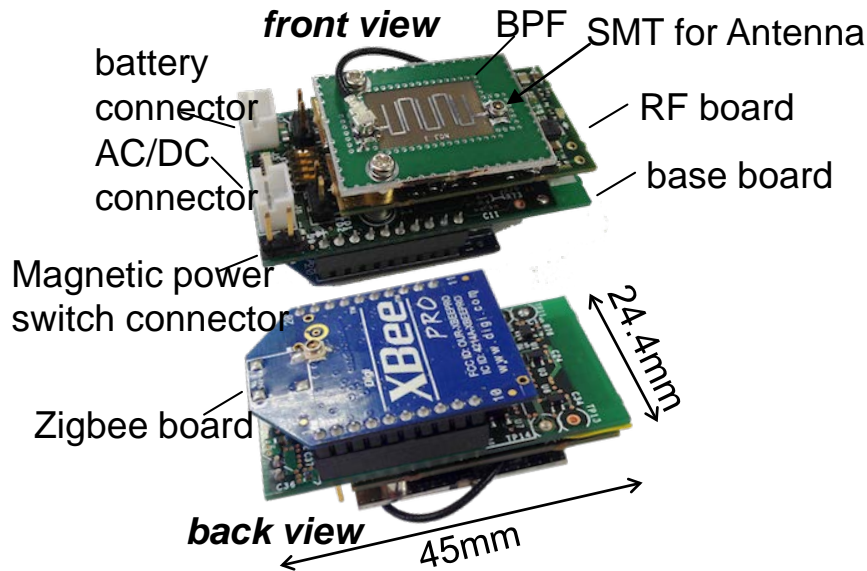
1st Generation (128ch)
 -ISM band (2.4GHz) [1.9Mbps]
 $12\text{bit} \times 1\text{kHz} \times 128\text{ch}$
 $= 1.5\text{ Mbps}$

2nd Generation (>4000ch)
 $12\text{bit} \times 1\text{kHz} \times 4096\text{ch}$
 $= 49\text{Mbps} \rightarrow \text{UWB}$
 (Ultra Wide Band)
 + Distributed system

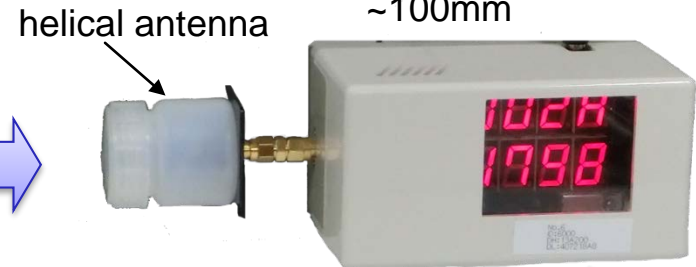
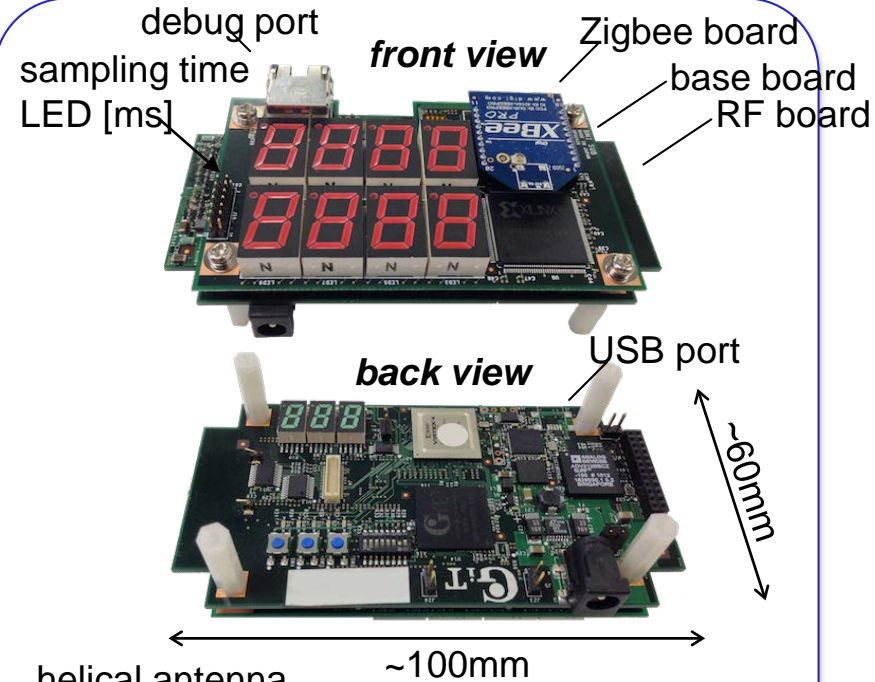
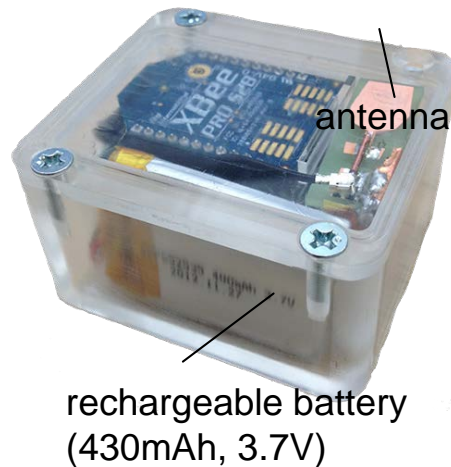
UWB system (4096ch) -Prototype-



UWB transmitter and receiver



Including UWB transmitter, BPF, antenna, Zigbee, Li-ion polymer battery

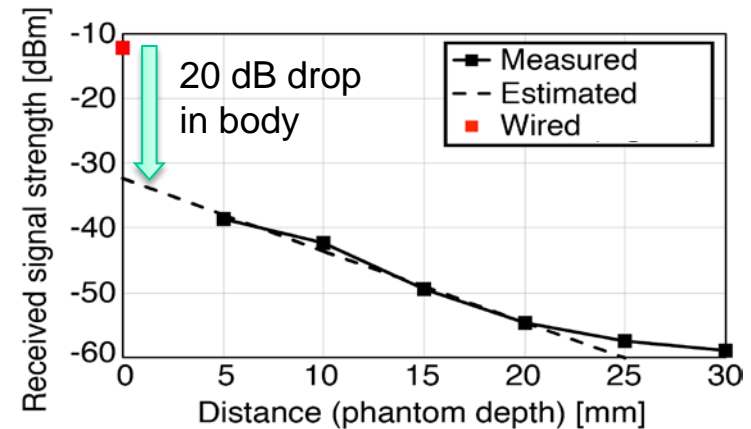
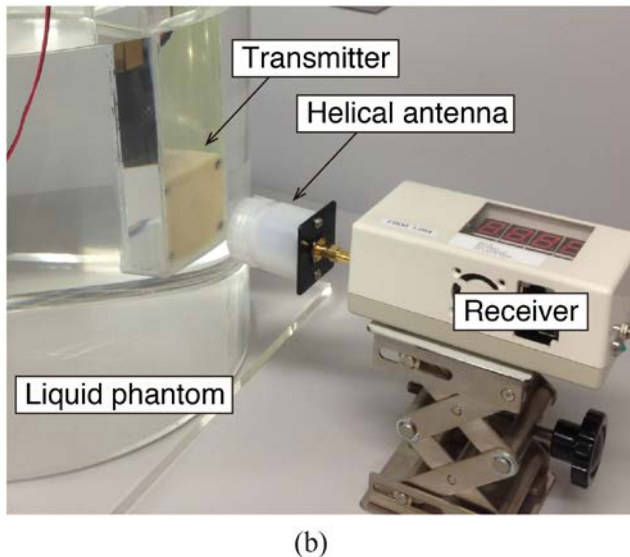
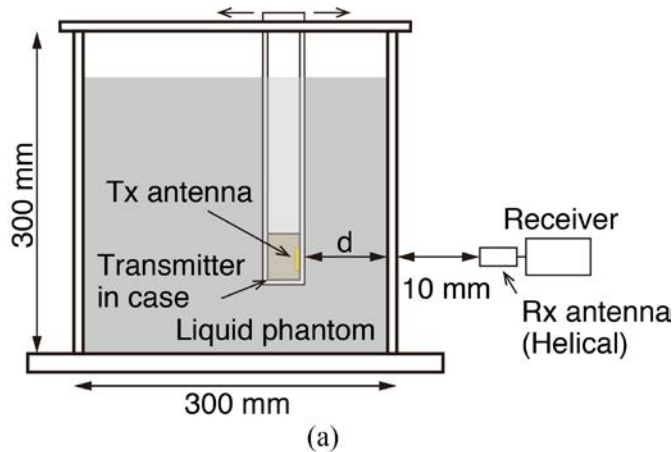


- Including UWB receiver, antenna, Zigbee unit
- Connected to PC by USB2.0
- Real-time Graphical view

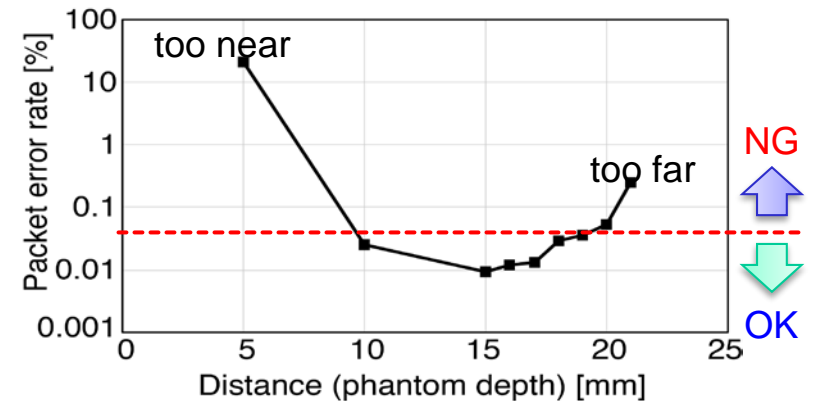
UWB system (Specification)

Number of channels	64~4096	ch	
Supply voltage	3.3	V	
Total power of implant devices	2.03	W	@4096ch (version 2014)
UWB bandwidth	7.275~8.525	GHz	for internationally usage
UWB data rate	128	Mbps	
MUX-A and MUX-B (common hardware)			
Xilinx Spartan6 XC6SLX16, FPC connector (11pin)			
UWB transmitter (water proof casing)			
RF, BPF and ZigBee board			
LVDS receiver (51.2Mbps), Magnetic Power SW (20mm range) and rechargeable Li polymer battery (400mAh)			
UWB receiver			
RF board, base board (Xilinx vertex4, USB2.0) and Zigbee board			
PC			
Core i7 3820 Win7 (USB2.0, GUI application)			

Evaluation of UWB in human equivalent liquid phantom



Measured characteristics of received signal strength.



Packet error rate with respect to the phantom depth.

128 Mbps UWB wireless communication is available below 20 mm between inside to outside body.

(a) Diagram and (b) photograph of the measurement setup.

Thank you for your attention