Redefining Neuroimaging Standard Of Care : An Implantable Ultrasound For Real-time Diagnosis Of Brain Diseases

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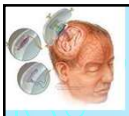
1



Neuroplastic Surgery Center

Goal: An Implantable Ultrasound Device For Real-time Diagnosis Of Brain Diseases

- To Develop the first implantable ultrasound device for long-term post-neurosurgical monitoring.
- The primary aim is to monitor the potential regrowth of brain tumor in real-time using an app. The ultrasound smart device will also assist physicians to monitor bleeding, cyst, growing tumor, etc., of the over 11 million patients that are affected annually with brain diseases.

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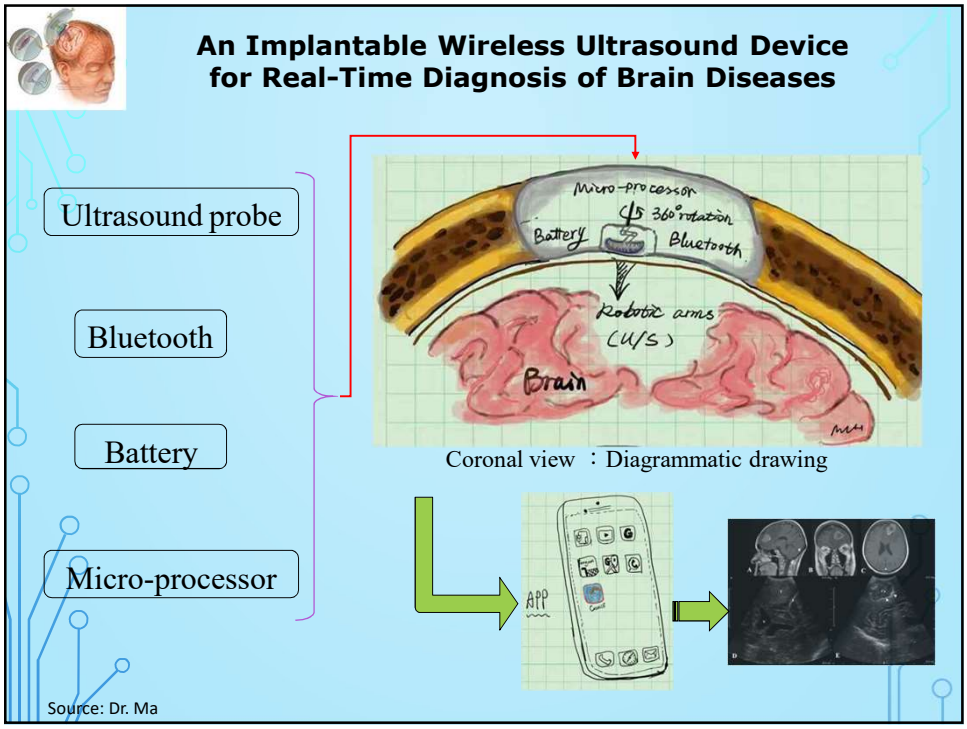
An Implantable Wireless Ultrasound Device for Real-Time Diagnosis of Brain Diseases
Ultrasound probe
Bluetooth
Battery
Micro-processor
Micro-processor
360° rotation
Battery
Bluetooth
Robotic arms (U/S)
Brain
Coronal view ：Diagrammatic drawing
APP
Source: Dr. Ma

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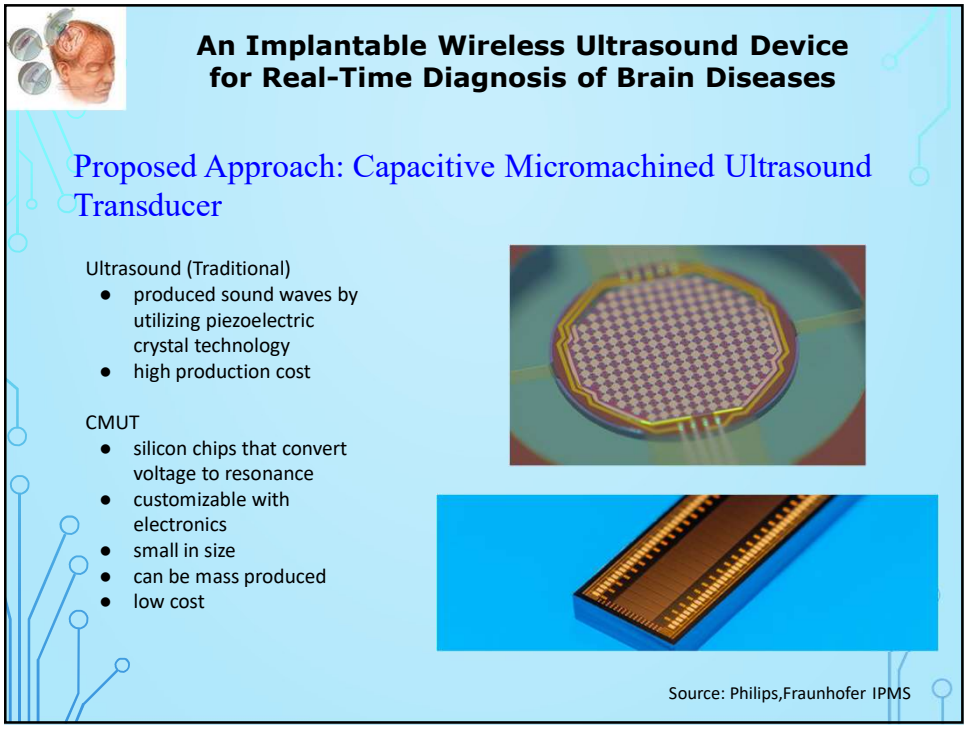
An Implantable Wireless Ultrasound Device for Real-Time Diagnosis of Brain Diseases
Proposed Approach: Capacitive Micromachined Ultrasound Transducer
Ultrasound (Traditional)
produced sound waves by utilizing piezoelectric crystal technology
high production cost
CMUT
silicon chips that convert voltage to resonance
customizable with electronics
small in size
can be mass produced
low cost
Source: Philips,Fraunhofer IPMS

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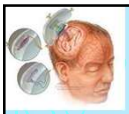

An Implantable Wireless Ultrasound Device for Real-Time Diagnosis of Brain Diseases

Selected Papers:

Miniature ultrasound ring array transducers for transcranial ultrasound neuromodulation of freely-moving small animals

Hyunggug Kim [a], Seongyeon Kim [a], Nam Suk Sim [b], Cristina Pasquinelli [c, d], Axel Thielscher [c, d], Jeong Ho Lee [b], Hyunjoo J. Lee [a, *]

micromachines

MDPI

Review

Advances in Capacitive Micromachined Ultrasonic Transducers

Kevin Brenner [1,†], Arif Sanli Ergun [1,2,†], Kamyar Firouzi [1,†], Morten Fischer Rasmussen [1,†], Quintin Stedman [1,†] and Butrus (Pierre) Khuri-Yakub [1,*,†]

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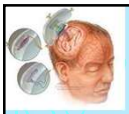


An Implantable Wireless Ultrasound Device for Real-Time Diagnosis of Brain Diseases

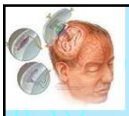
CMUT Background

- Each CMUT element consists of parallel cells
- flexible top plate and fixed bottom plate forms a capacitor
- interacts with a medium like air or water to radiate or sense ultrasound

Figure 1. Capacitive micromachined ultrasonic transducer (CMUT) cell illustration. (**a**) A CMUT cell is composed of a flexible top plate and a fixed bottom plate. (**b**) A direct current (DC) bias is applied during the operation that deflects the top plate.

Source: Brenner K, Ergun A, Firouzi K, et al.

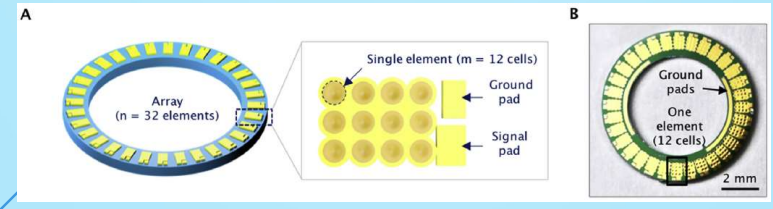
6



An Implantable Wireless Ultrasound Device for Real-Time Diagnosis of Brain Diseases

Selected Paper: Miniature Ultrasound Ring Array Transducer for Transcranial Ultrasound Neuromodulation of Freely-Moving Small Animals

- Problem: Due to bulky curved transducers, small animals have been limited to stimulation under anesthesia in a stereotactic fixation
- Key result: Neuromodulation using a light-weight CMUT ring array for non-invasive brain stimulation for acute and awake in vivo mice



Source: Kim H, Kim S, Sim N, et al.

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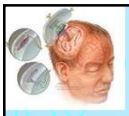

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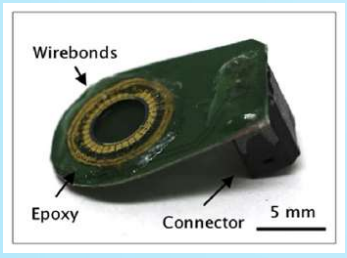

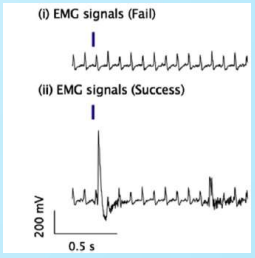

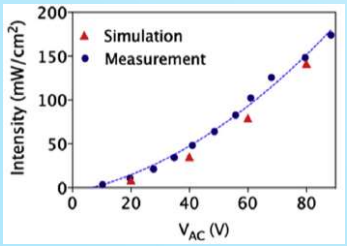

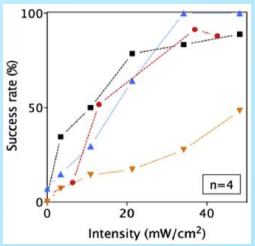

Source: Kim H, Kim S, Sim N, et al.

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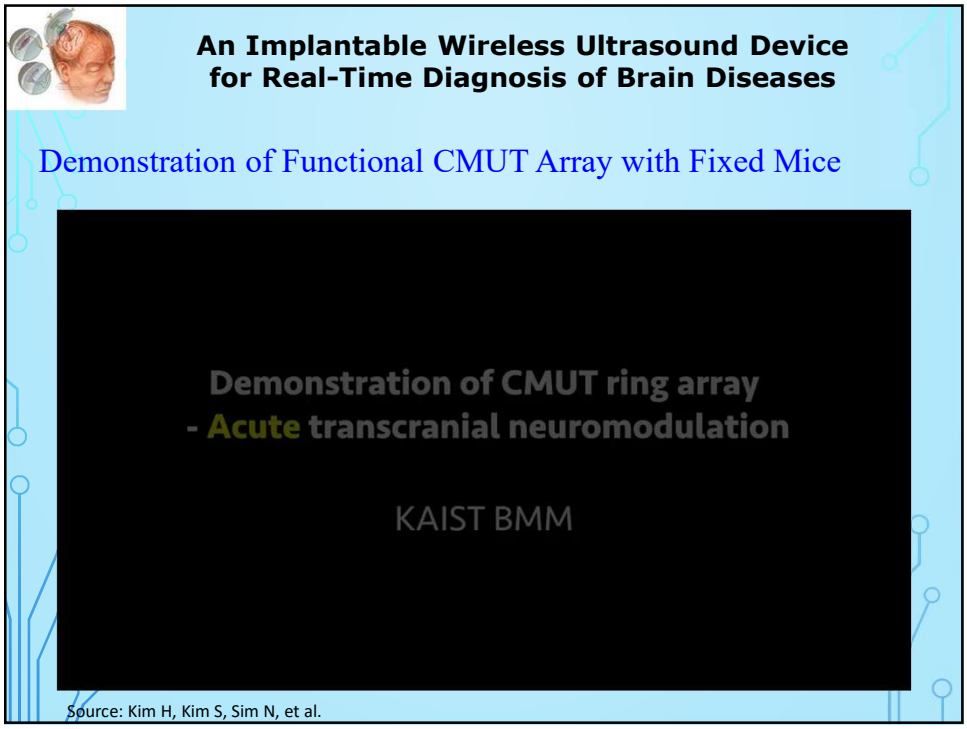
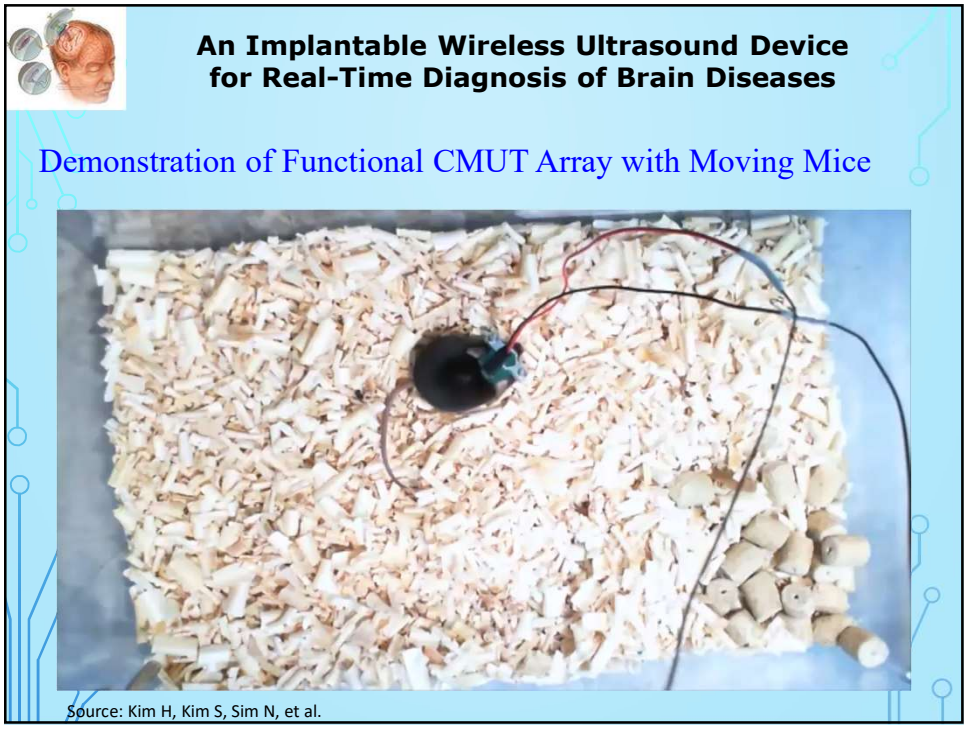
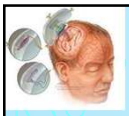

An Implantable Wireless Ultrasound Device
for Real-Time Diagnosis of Brain Diseases
Demonstration of Functional CMUT Array with Fixed Mice
Demonstration of CMUT ring array
- Acute transcranial neuromodulation
KAIST BMM
Source: Kim H, Kim S, Sim N, et al.

9


An Implantable Wireless Ultrasound Device
for Real-Time Diagnosis of Brain Diseases
Demonstration of Functional CMUT Array with Moving Mice
Source: Kim H, Kim S, Sim N, et al.

10



An Implantable Wireless Ultrasound Device for Real-Time Diagnosis of Brain Diseases

Assessment

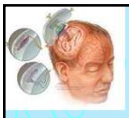
Importance: first in vivo neuromodulation of freely moving mice

Relevance: fabrication of the MR conditional CMUT array

Remaining problems: entire device is not completely MR conditional, does not perform any beamforming

Next steps: Integrate with beamforming circuits and dynamic focusing

11



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Advantages of CMUT – Imaging On a Chip

Integrating CMUTs with circuitry on a single chip is a revolutionary path to low cost, actually portable ultrasound systems.

- Integrating with wireless communication and battery technology can create flexible, wearable or even ingestible US systems

Source: Brenner K, Ergun A, Firouzi K, et al., Butterfly iQ Network

12