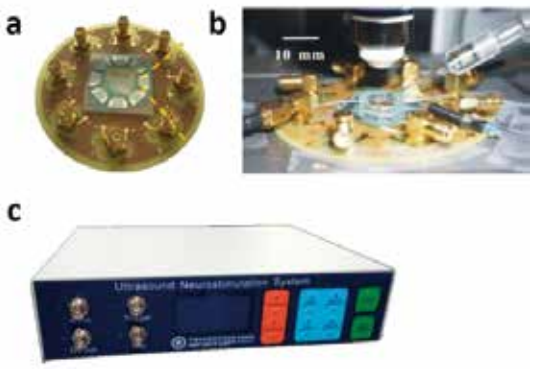
Materials

A Portable Multi-scale Ultrasound System for Brain Detection

A group of researchers led by ZHENG Hairong from the Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences (SIAT) have recently made major progress in developing multi-scale ultrasound neuromodulation systems. Their paper, "A Portable Ultrasound System for Non-Invasive Ultrasonic Neuro-Stimulation", was published in *IEEE Transactions on Neural Systems and Rehabilitation Engineering* and later reported in a review paper by *Nature*.

Recent studies have shown that ultrasound has the ability to modulate neural activity in a non-invasive manner. By transmitting acoustic waveforms into brain tissue, ultrasound is able to non-invasively and remotely stimulate the neurons by activating voltage-gated sodium channels. The ultrasound induced changes in neuronal activity are sufficient to trigger synaptic transmission in intact brain circuits. Ultrasound has also been demonstrated useful for the stimulation of retina. The inter-neurons beyond photoreceptors were activated to potentially restore some sense of vision. The most recent studies on human brain presented that the ultrasound could enhance the performance on sensory discrimination without affecting task attention or response bias. The sonication elicited transient tactile sensations on the hand area contralateral to the sonicated hemisphere. Therefore, ultrasound has been demonstrated for different scales of neuro-stimulation from single neuron to human brain, which offers a powerful tool for remotely modulating neural activity with non-invasive feature.

The ultrasound research team at SIAT lately developed a portable ultrasound system specifically for ultrasound neuromodulation applications. The ultrasound physical parameters including the operating mode, frequency, pulse repetition frequency, intensity and pulse duration are adjustable in a friendly manner. The newly developed system supports the synchronization of input and output to facilitate with other neurophysiological devices such as MEA, or patch clamp. The new ultrasound neuro-modulation equipment has already been used for the modulation of small animal and non-human primates.



(a-b) Micro-scale ultrasound stimulation chip, and (c) A portable ultrasound neurostimulation system.

Large scale (thousands of channels) ultrasound transducer and system specifically for ultrasound neuromodulation.

Meanwhile, researchers have developed several new devices and systems for multi-scale ultrasound

neuromodulation applications including research with neuron, small animal, and non-human primate. Moreover, 2,048 elements MRI-compatible ultrasound transducer and system have also been developed, which provide the basis for multi-point dynamic deep brain stimulation.

At present, the developed ultrasound neuromodulation techniques and equipment by SIAT have been successfully applied in several renowned neuroscience laboratories include Zhejiang University, Tsinghua University, Shanghai Jiaotong University, Hong Kong Polytechnic University, University of Southern California, as well as the Kunming Institute of Zoology and Shanghai Institute of Neurology and Psychology under the Chinese Academy of Sciences. The developed ultrasound systems will play a key role in the study of key technologies such as the non-invasive neuro-modulation and sonogenetics.

Their research was supported by the National Science Foundation of China, the National Basic Research Program of China, the Chinese Academy of Sciences, and Guangdong provincial government and Shenzhen municipal government.