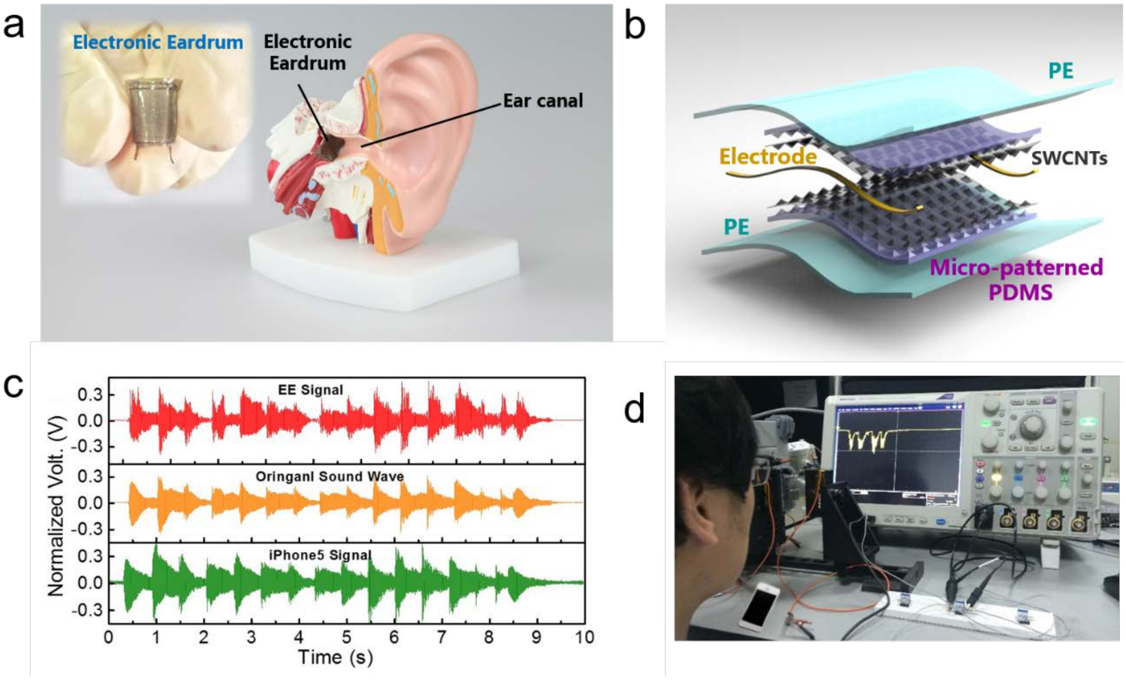
Flexible nanoelectronic eardrum

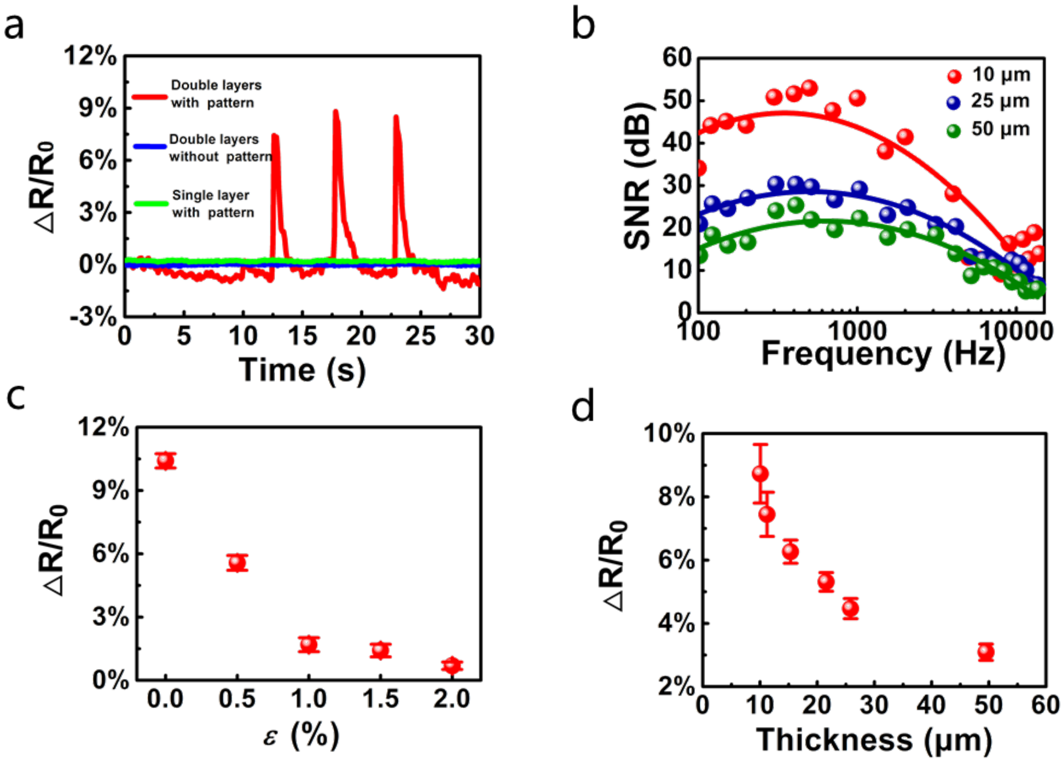
The eardrum, also called the tympanic membrane or myringa is a thin, cone-shaped membrane that play the crucial role in sensing sound and transmit the sound from the air to the ossicles. For electronic ear to “hear” sound, traditionally, the rigid diaphragm in microphone was used to detect sound, however the planar and rigid format limited it’s in vivo applications. It is necessary to simulate a flexible eardrum responding to sound/voice vibration in suspended state with similar flexible mechanic properties, wide frequency response domain, high sensitivity and ultra-fast response time for real-time detection and recording.

Recently, researchers from the Suzhou Institute of Nanotech and Nanobionics (SINANO), Chinese Academy of Sciences (CAS), developed a novel flexible electronic eardrum to detect sound signal based on single-walled carbon nanotubes, poly-ethylene (PE) and poly-dimethylsiloxane (PDMS) with micro-structured pyramid arrays. The EE device shows high sensitivity, high signal-to-noise ratio (~55 dB), and fast response time (76.9 μs) to detect and record sound within 20–13,000 Hz frequency domain.

By optimizing the chosen materials and micro-structure design, the ultra-thin flexible mechano-sensors were fabricated to detect sound signal. The PE-PDMS thin films were prepared by using ultra-violet ozone treated PE, PE and PDMS were combined by chemical bonding, which realized the ultra-thin (50 μm) and ultra-light (50 mg) sensor. The introduction of the pyramid microstructure significantly improved the sensing performance to sound. By analyzing the recorded sound signal, the sensors were found that the recorded signal has a high degree of consistency with the original audio signal. The theoretical calculation and experiment indicated that the mechanism of sensing sound was different between flexible piezoresistive sensors in response to the normal pressure. The sound response was affected by sensors’ thickness, stress state and micro structure. Finally, the ultra-thin flexible mechanical sensors were used to identify the sound of different people by wavelet transform.



a, Image of the flexible electronic eardrum placed in an ear model. The inset figure shows the image of the bended electronic eardrum. **b,** Schematic configuration of the electronic eardrum. **c,** The band-pass filtered electronic eardrum signal was compared with original sound wave and iPhone5 signal. **d,** A picture showing the voice recognition experiment. The electronic eardrum was suspended by clamps in front of the participant to detect his voice and the signal was recorded by oscilloscope.



a, The Double-layer electronic eardrum with/without micro pattern (in red and orange, respectively) and single PE-PDMS film (green) based device were tested under the same sound. **b**, The frequency response of the electronic eardrum with different side length of pyramid structure 10 (in red), 25 (in blue) and 50 (in green) μm. **c and d**, The sensitivity of the electronic eardrum changes with different strain states and thickness of the PDMS layers respectivly.

The result has been published online in *Nano Res.* 2017, DOI: 10.1007/s12274-017-1470-1.

This work was featured on PE world and CAS websites.
http://www.printedelectronicsworld.com/articles/11127/flexible-electronic-eardrum
http://english.cas.ac.cn/newsroom/research_news/201706/t20170601_177644.shtml

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