Supplementary Information (SI) for Nanoscale.

Electronic Supplementary Information

Enhancing Acoustoelectric Conversion of Nanofiber Transducer in Combination with Kazoo†

Kang Wang, Lu Peng, Peng Jiang, Le Xu, Lianghui Li, Hongxia Wang, Xin Jin, Wenyu Wang, Tong Lin*

1. School of Textile Science and Engineering, Key Laboratory of Frontier Fiber Membrane Materials, Tiangong University, Tianjin 300387, China
2. The Key Laboratory of Hollow Fiber Membrane Materials and Membrane Processes, Ministry of Education, Tiangong University, Tianjin 300387, China.
3. Hebei Industrial Technology Research Institute of Membranes, Cangzhou Institute of Tiangong University, Cangzhou, 061000, China

Corresponding author's Email: tong.lin@tiangong.edu.cn

FEM analysis details

The material settings were defined as follows:

Material \ Property	Density kg/m³	Young's modulus Pa	Poisson's ratio
PVDF	1780	69M	0.35
PET film	1420	3G	0.35
PMMA	1190	3G	0.40

The software determined the sound velocity and Young's modulus.

The frequency domain was adjusted to increase the hard field boundary with the internal hard field boundary using plane wave radiation as the sound source in a pressure acoustic setting. A low-frequency sound source (50-500 Hz) at 0.2-11.2 Pa was selected to simulate the sound acquisition conditions, and the resonant frequency was determined by frequency sweeping.

The model used the Acousto-Piezoelectric Interaction, Frequency Domain Multiphysical Field interface, which includes the solid mechanics and acoustic pressure interfaces. The acoustic-structural interface allowed the coupling of air to the PVDF membrane. In the solid mechanics interface, the boundary conditions of the PVDF membrane were set as fixed constraints, and the perimeter of the membrane was selected. In the pressure-acoustic interface, a perfectly matched cylindrical layer was used as a boundary condition around the cylindrical air domain to ensure sound absorption by the air. The radiation boundary "incident pressure field" was set at the front of the air domain.

To ensure the authenticity of the simulation results while minimizing the time and computational space required, the maximum mesh cell size was set to 1/5 of the minimum sound wavelength in the air domain. The mesh size was set to 340 [m/s]/1000 [Hz]/5 (the frequency used in this simulation does not exceed 500 [Hz]), the number of vertex elements was 44, the number of edge elements was 450, the number of boundary elements was 6562, the number of elements was 9681, the minimum element mass was 0.01112. The number of solution degrees of freedom was 73010.

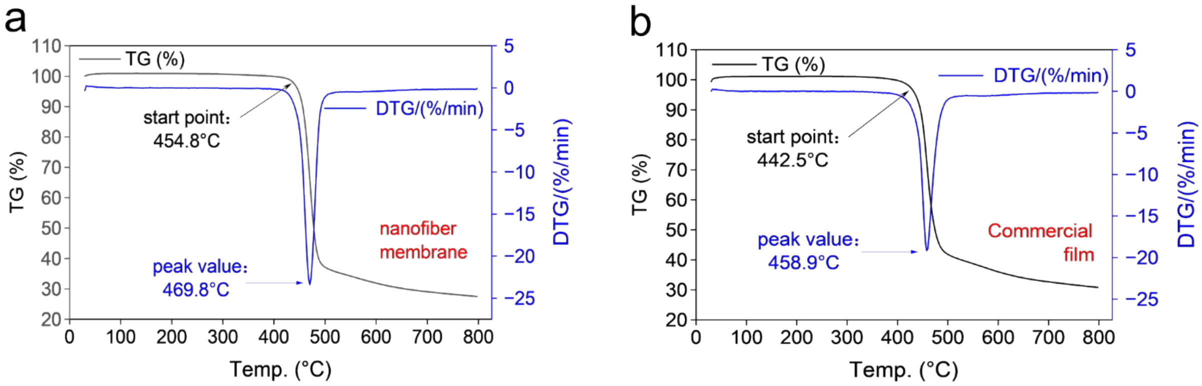

Fig. S1 (a) TG and DTG diagrams of PVDF nanofiber membranes, (b) TG and DTG diagrams of commercial PVDF film.

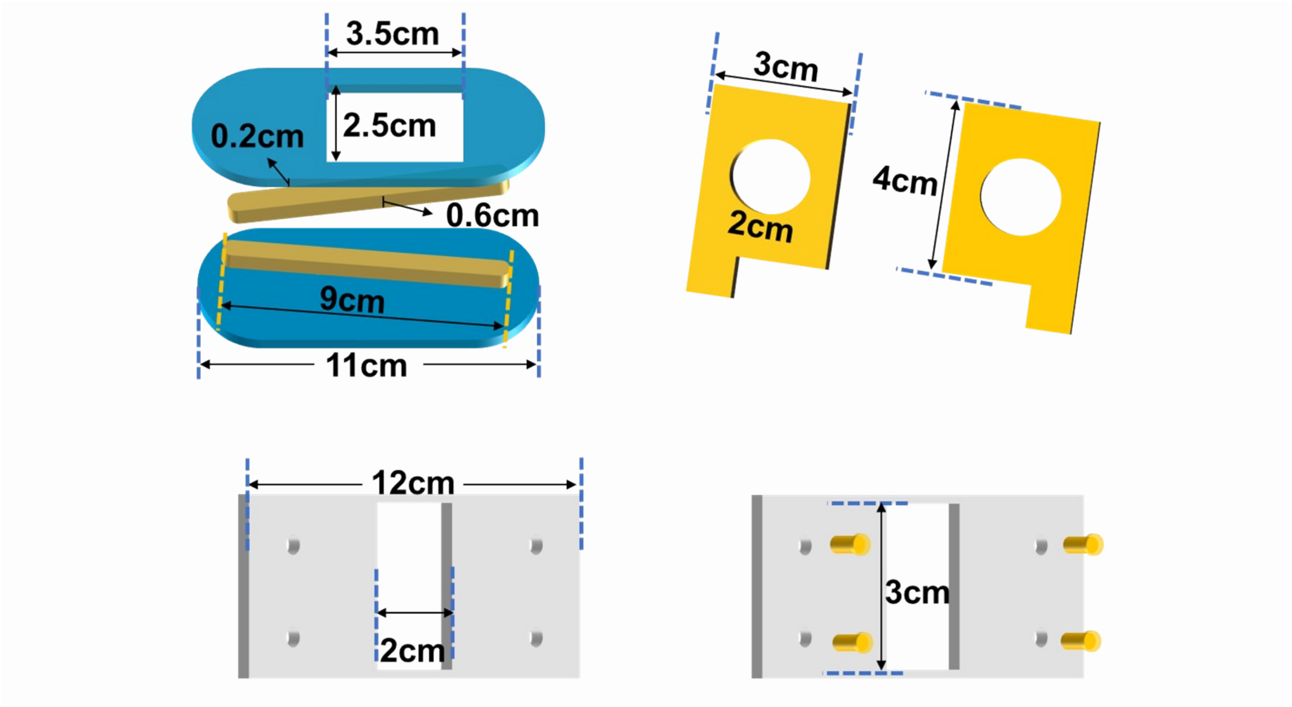

Fig. S2 Schematic diagram of the specific dimensions of the kazoo generator.

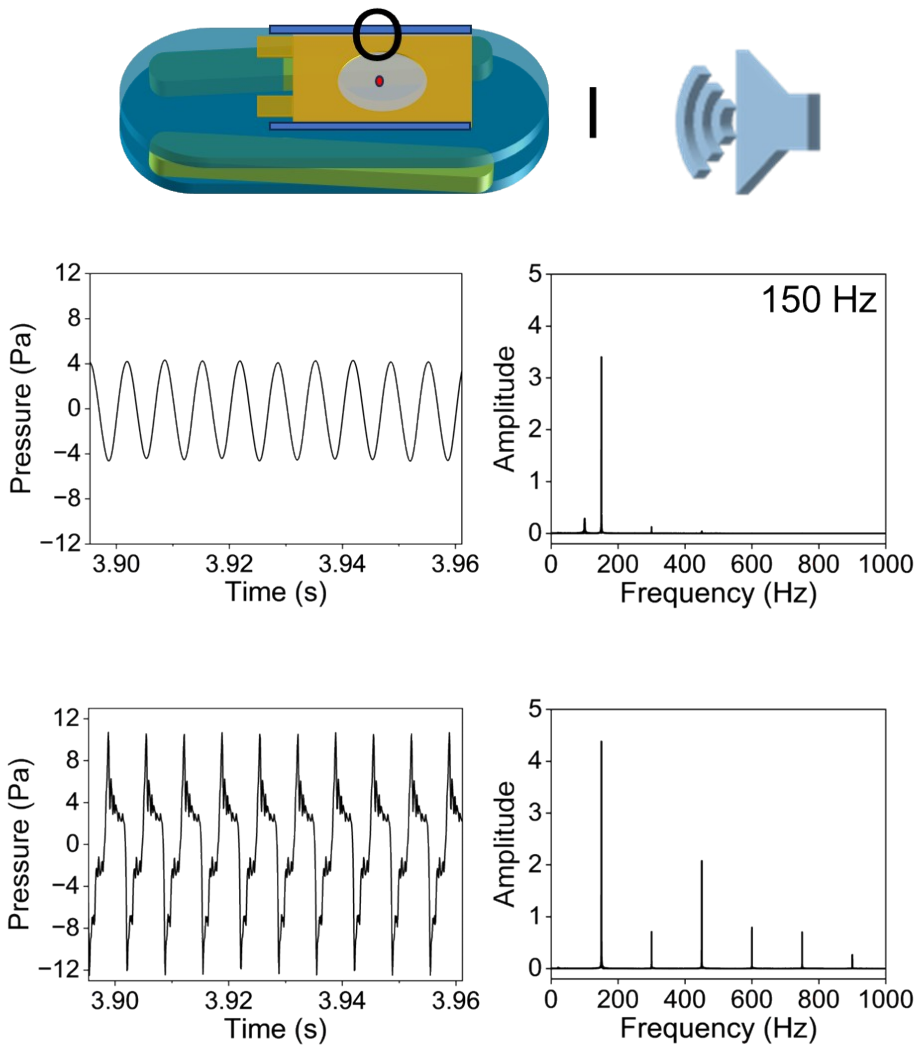

Fig. S3 Sound pressure waveform and its frequency profile at the kazoo entry (Site I) and the nanofiber (Site O) (sound frequency 150 Hz).

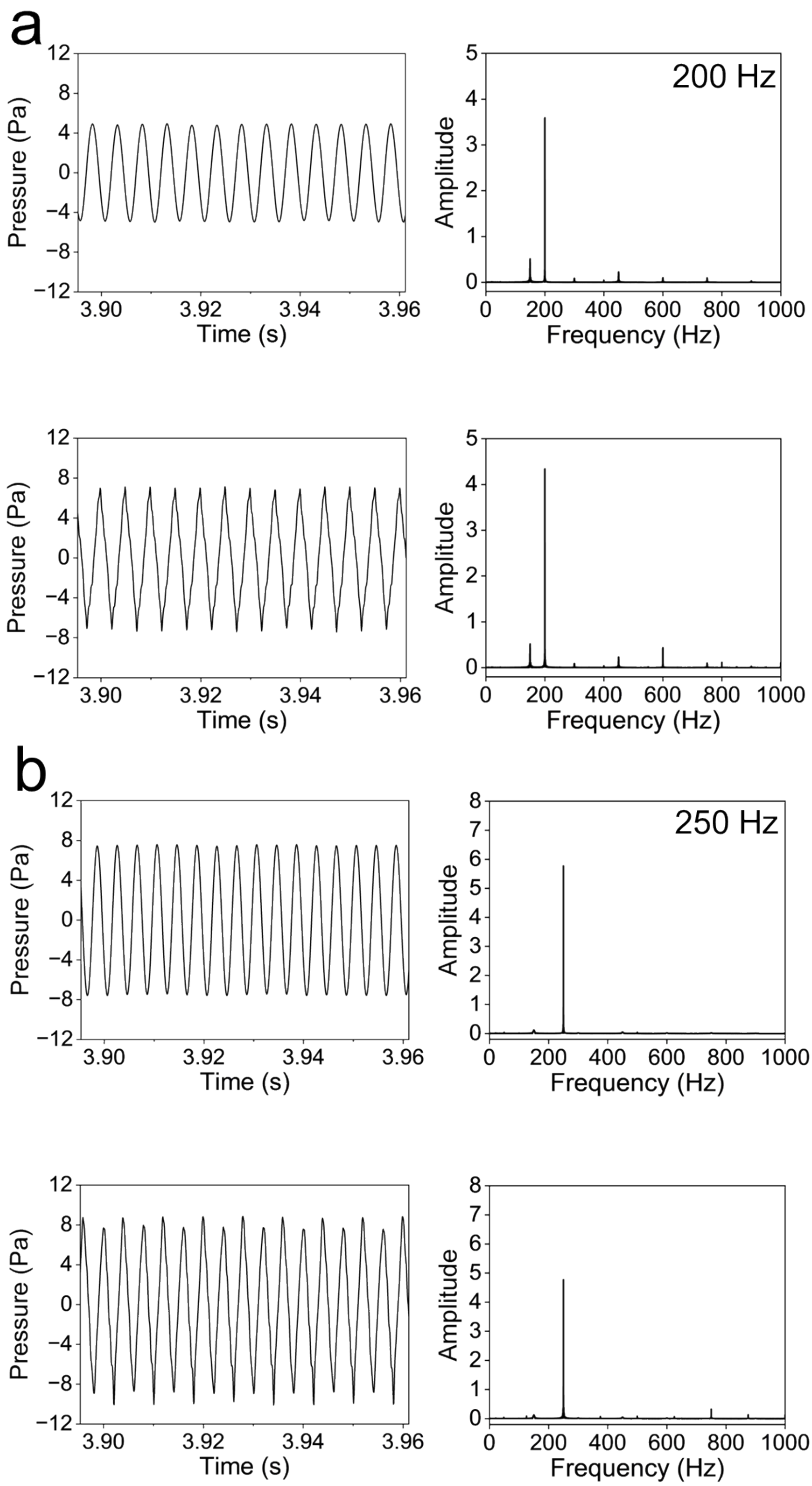

Fig. S4 Sound pressure waveform and its frequency profile at the kazoo entry (Site I) and the nanofiber (Site O) (sound frequencies (a) 200 Hz and (b) 250 Hz).

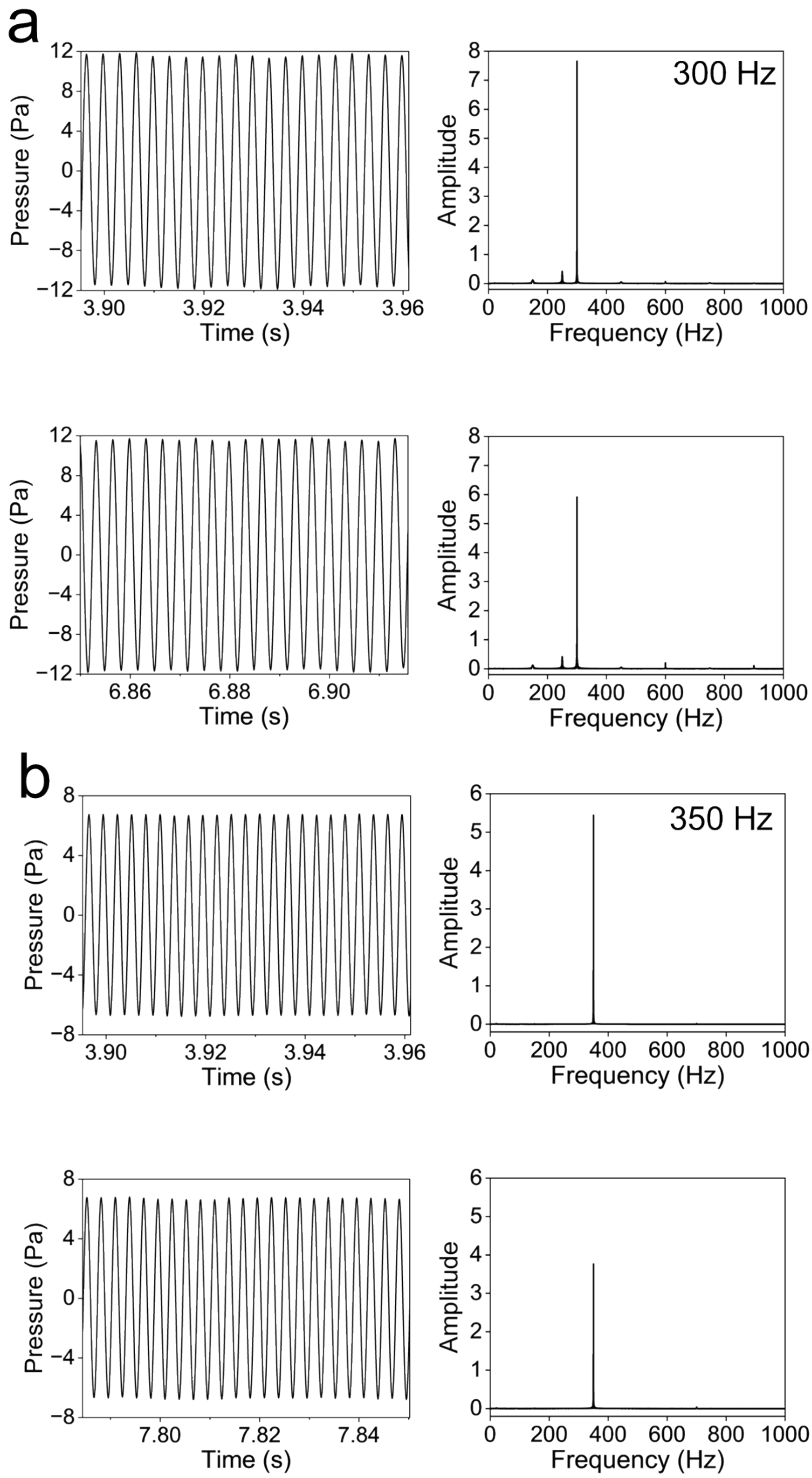

Fig. S5 Sound pressure waveform and its frequency profile at the kazoo entry (Site I) and the nanofiber (Site O) (sound frequencies, (a) 300 Hz and (b) 350 Hz).

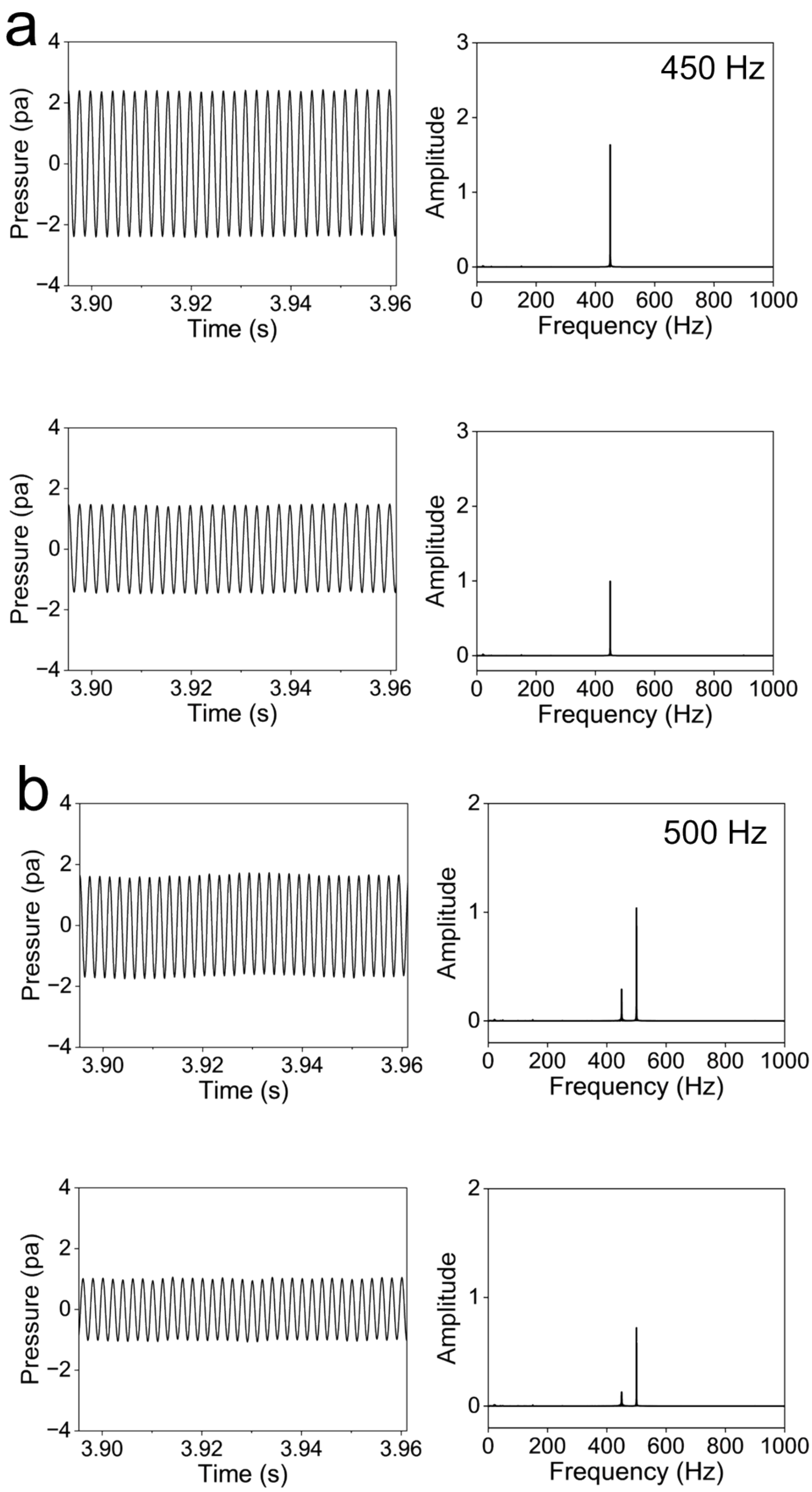

Fig. S6 Sound pressure waveform and its frequency profile at the kazoo entry (Site I) and the nanofiber (Site O) (sound frequencies, (a) 450 Hz and (b) 500 Hz).

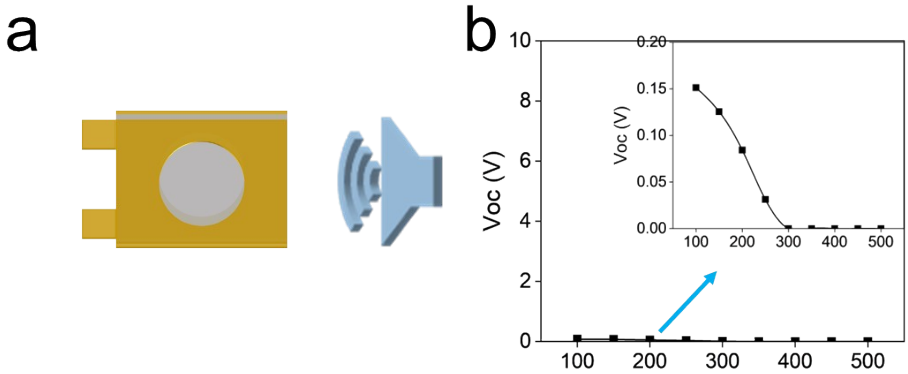

Fig. S7 (a) Schematic diagram to illustrate the test of nanofiber transducer in parallel sound incidence mode, and (b) Frequency spectra at 80 dB.

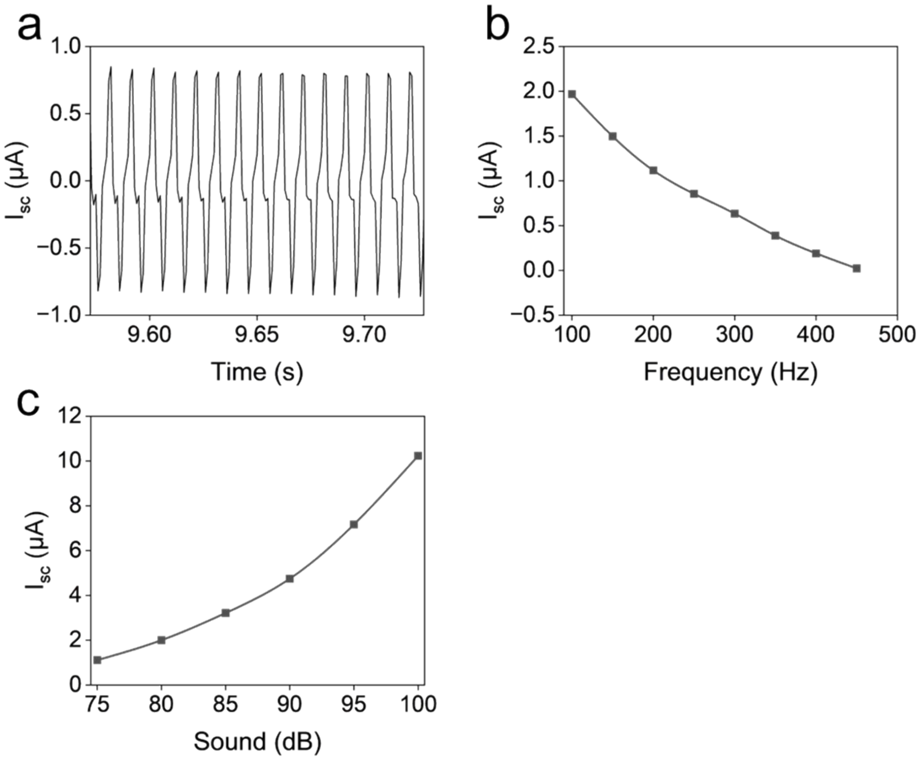

Fig. S8 (a) Short current output (I_{sc}) at 80 dB, 100 Hz sound condition; (b) I_{sc} frequency spectrum (SPL 80 dB); and (c) SPL response (sound frequency 100 Hz) of the kazoo generator.

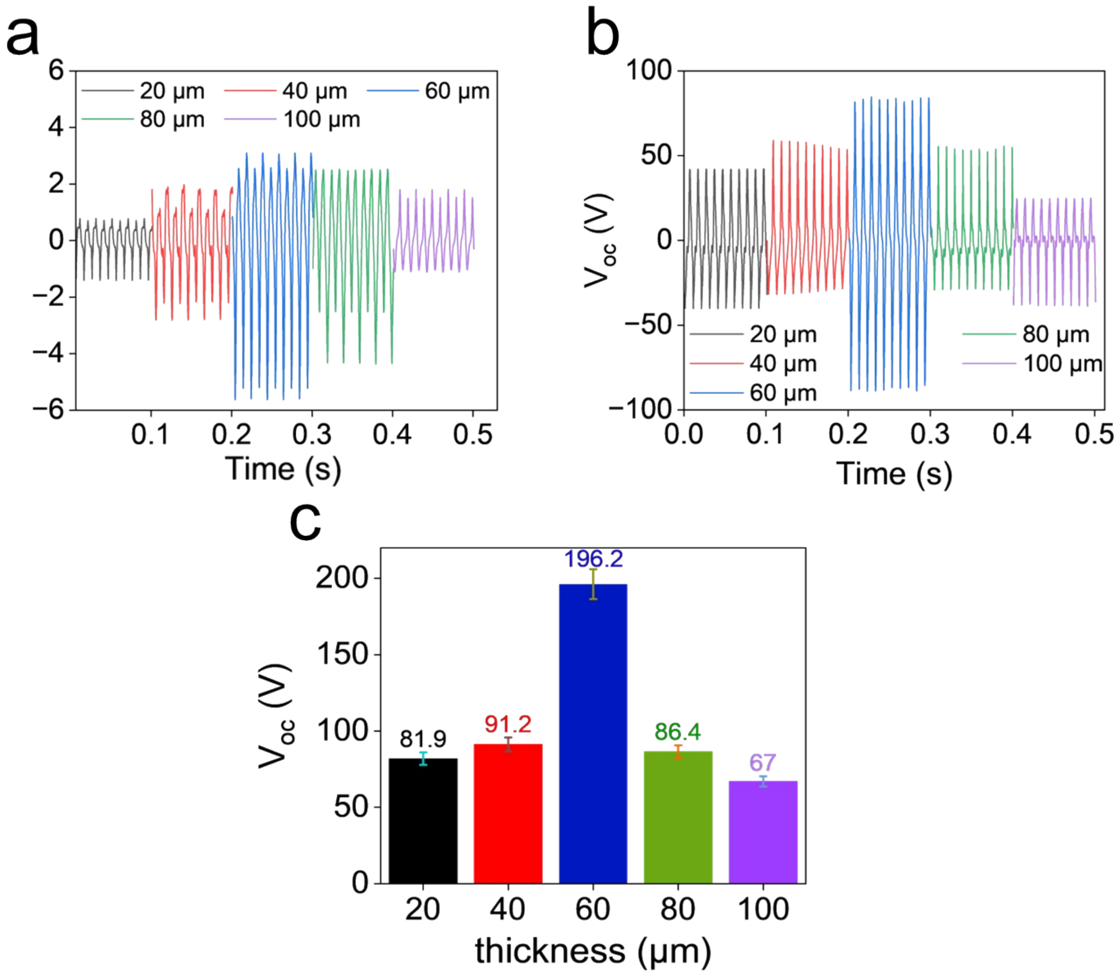

Fig. S9 The effect of nanofiber membrane thickness on Voc-pp under the sound condition of (a) 100 Hz/80 dB, (b) 100 Hz/115 dB. (c) The effect of thickness on Voc.

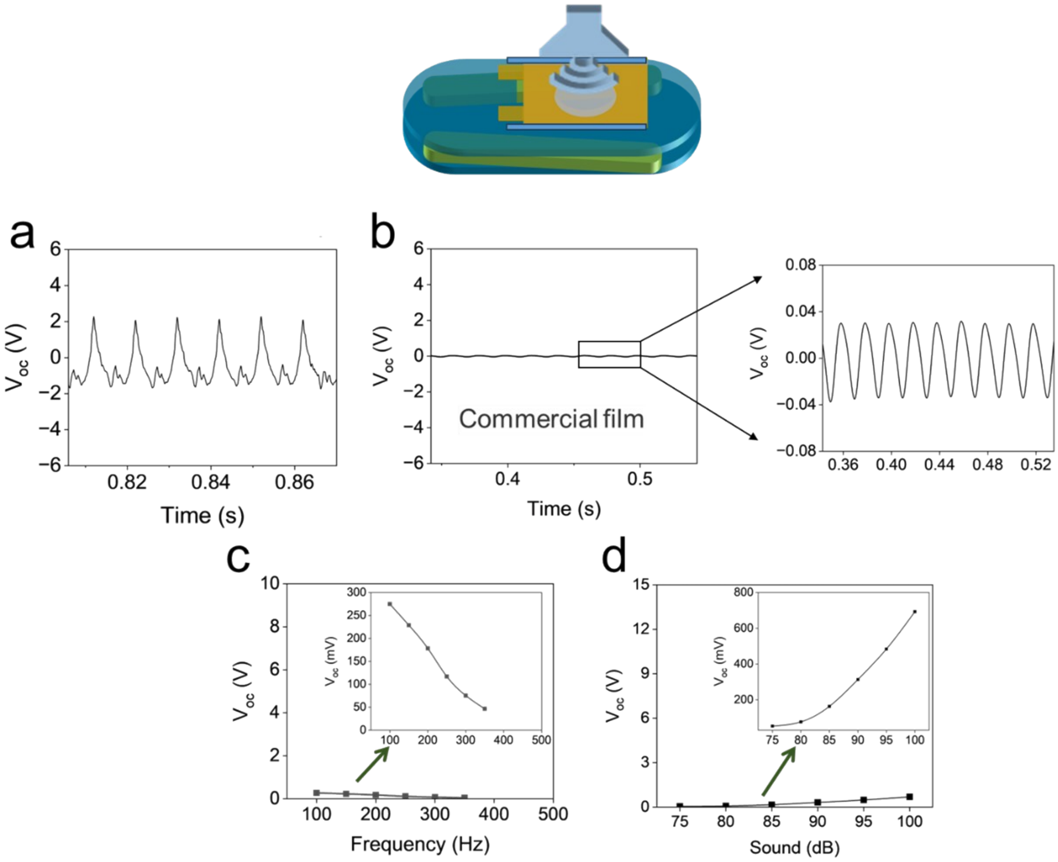

Fig. S10 Voc waveforms of kazoo with the commercial PVDF film under (a) 115 dB/100 Hz and (b) 80 dB/100 Hz sound conditions and enlarged b. (c) frequency spectra (80 dB) and (d) SPL response (100 Hz).

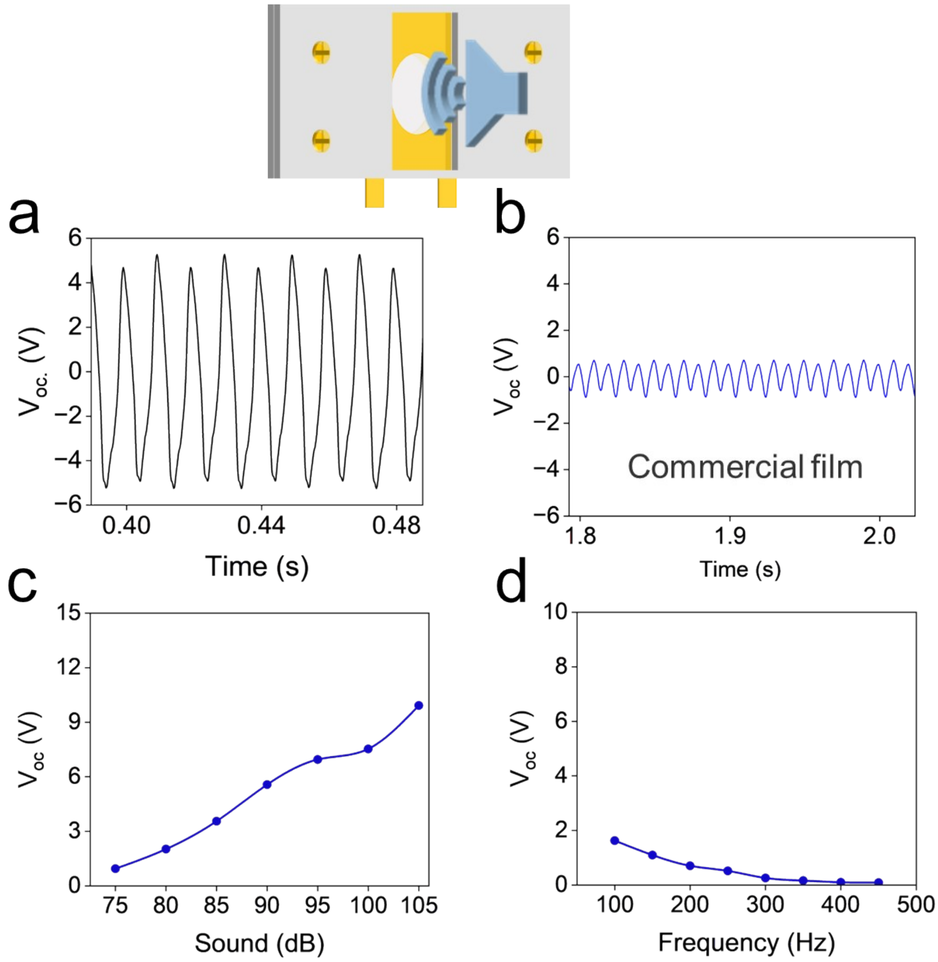

Fig. S11 Voc waveforms at (a) 100 Hz/115 dB and (b) 100 Hz/80 dB for the commercial PVDF film transducer at vertical sound incidence mode. (c) SPL response (80 dB) and (d) frequency spectrum (100 Hz).

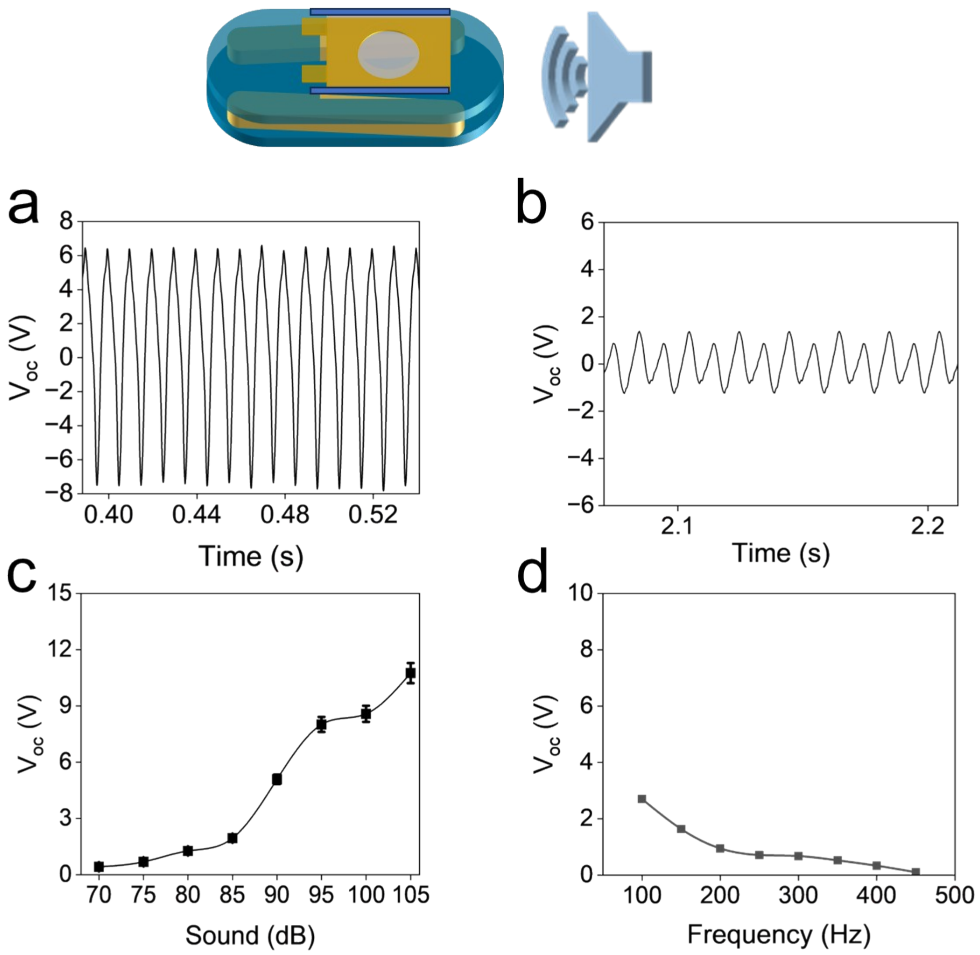

Fig. S12 Voc waveform of the kazoo with a commercial PVDF film under (a) 100 Hz/115 dB, and (b) 100 Hz/80 dB sound conditions. (c) SPL response (100 Hz) and (d) frequency spectrum (80 dB).

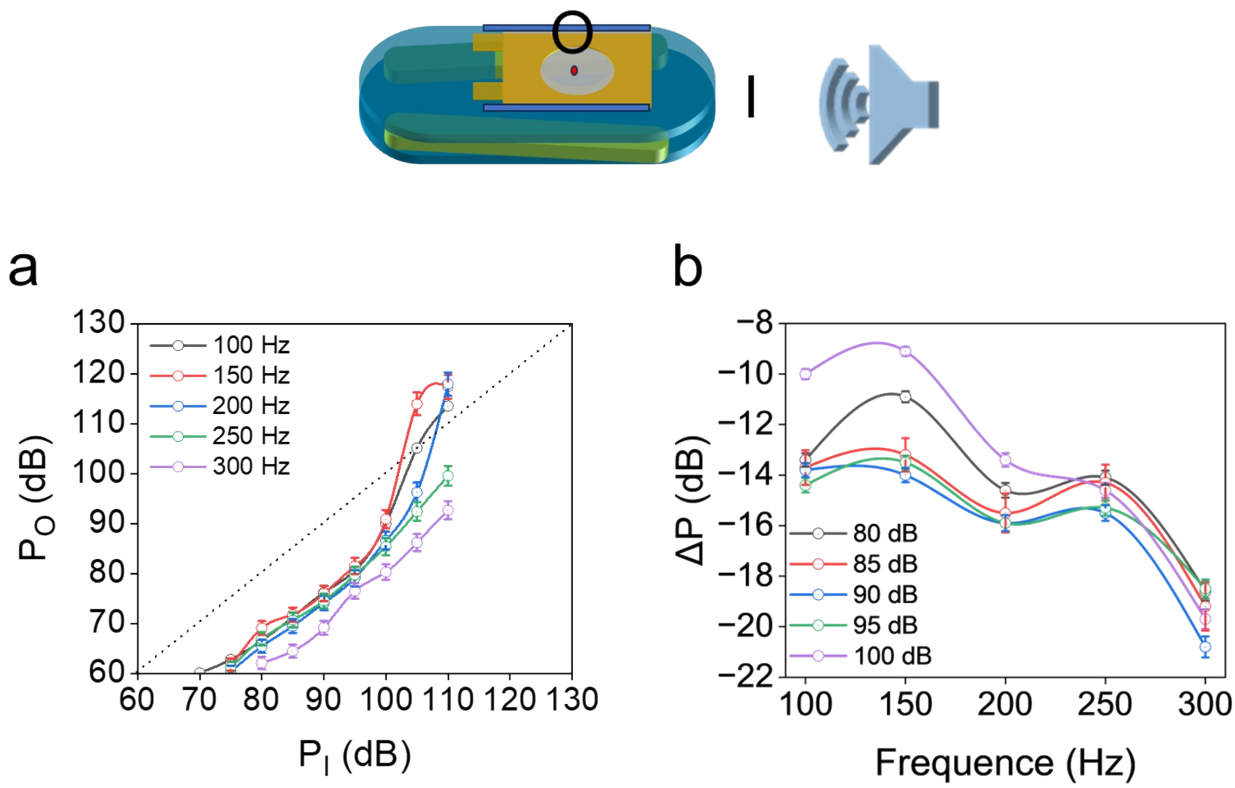

Fig. S13 (a) $P_O \sim P_I$ and (b) $\Delta P \sim$frequency relationships for the kazoo with an aluminum foil diaphragm.

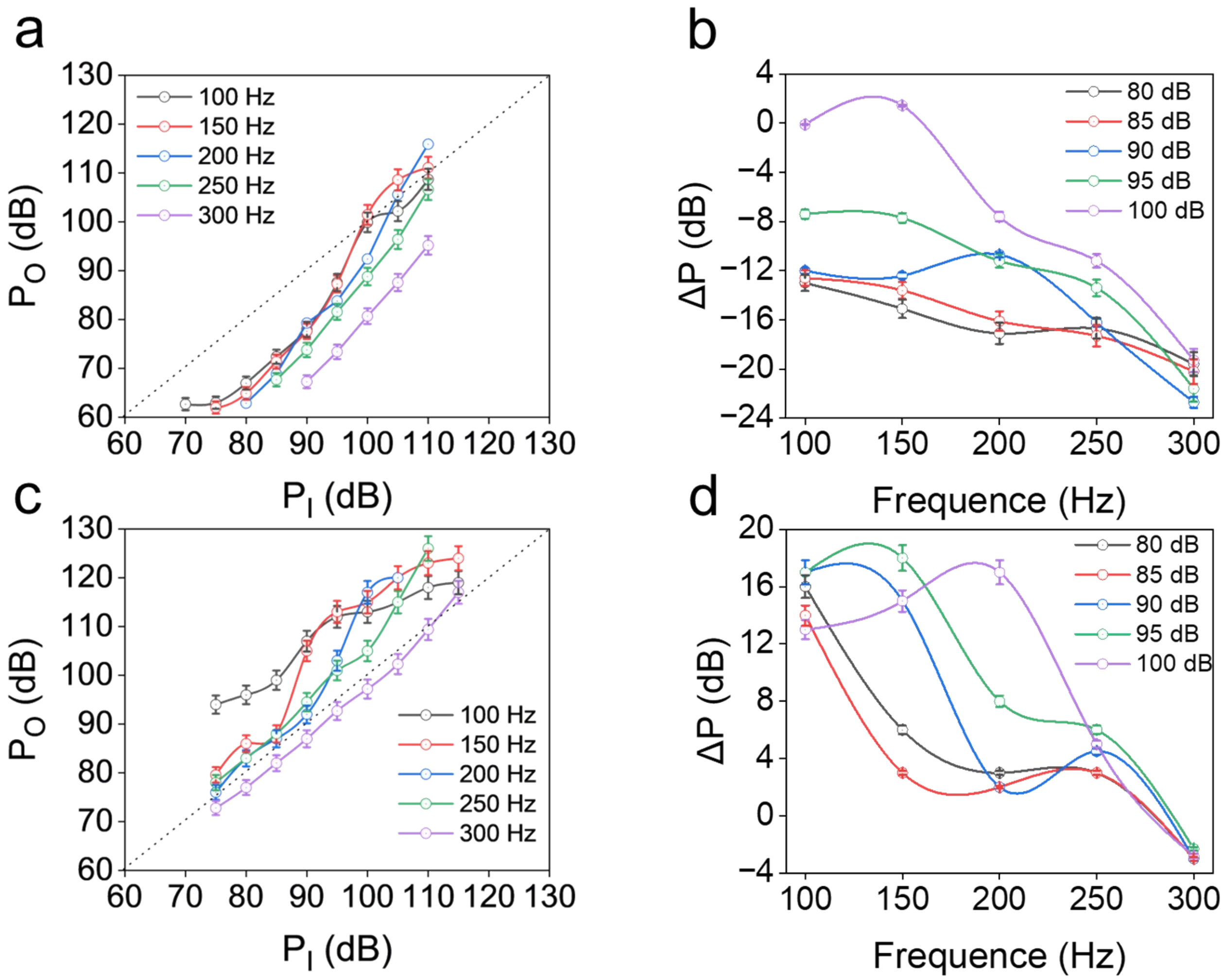

Fig. S14 (a) Po~P_I and (b) ΔP~frequency relationships for the kazoo with an A4 paper diaphragm; (c) Po~P_I and (d) ΔP~frequency relationships for the kazoo with a PE film diaphragm.

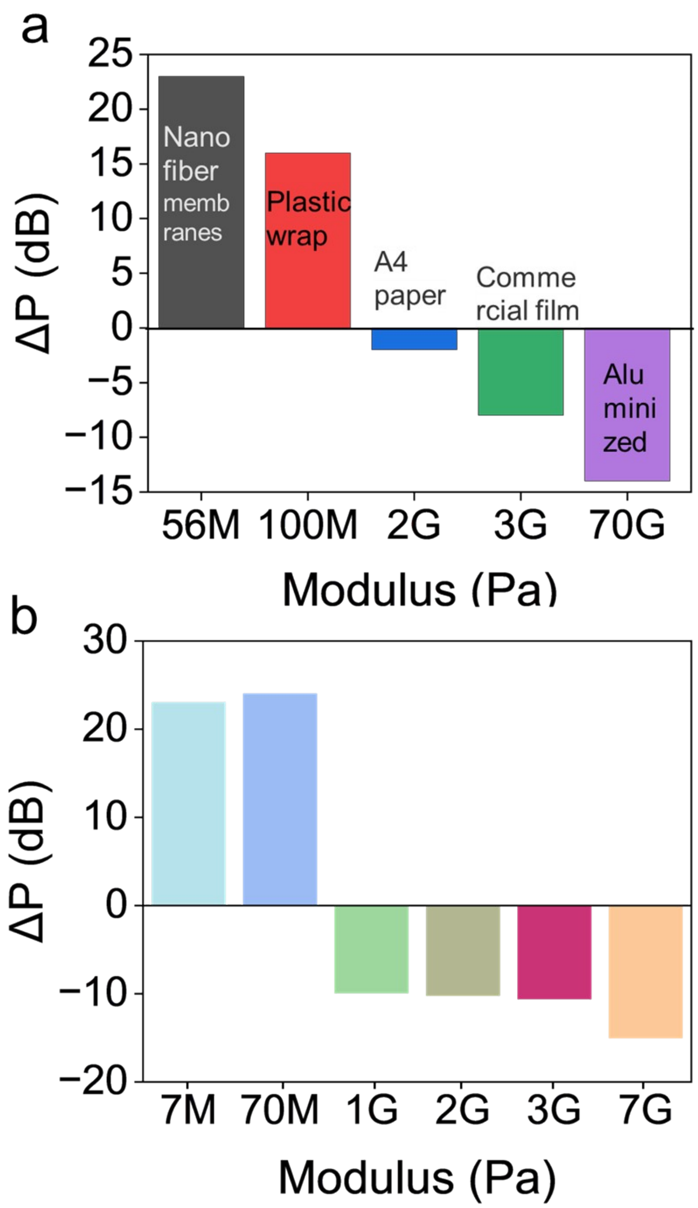

Fig. S15 (a) The relationship between Young's modulus and ΔP for the kazoo with different diaphragm materials. (b) FEM calculation result of ΔP~ Young's modulus.

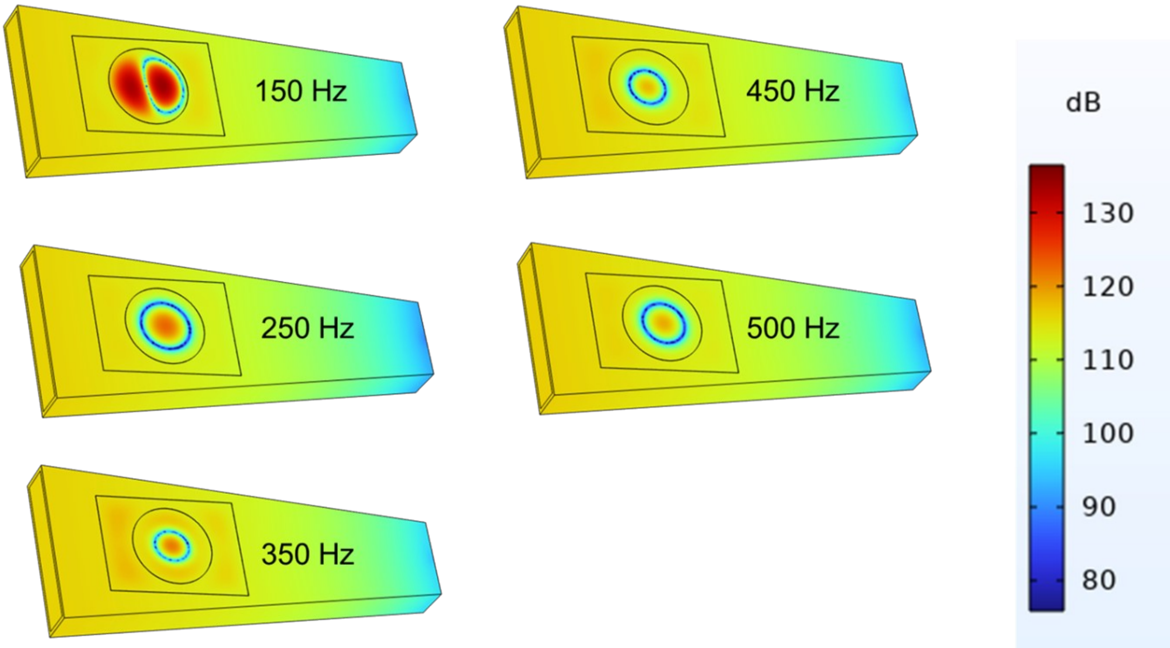

Fig. S16 The simulation results chart and unit legend for the frequency range of 150 Hz to 500 Hz, under the incident sound pressure of 115 dB.

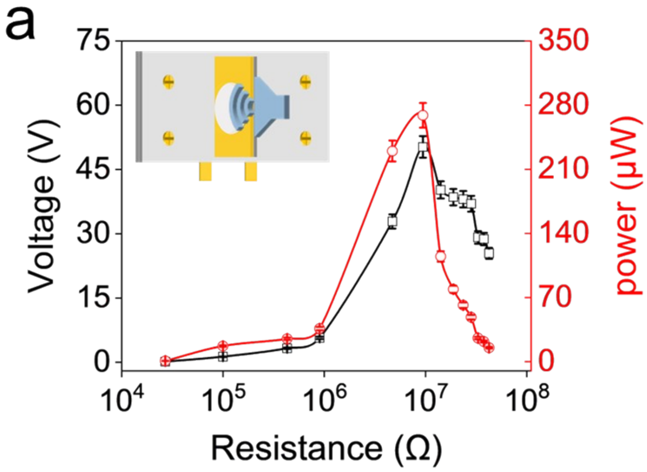

Fig. S17 Voc~R and P~R relationships for the nanofiber transducer working in vertical incidence mode. The maximum voltage (50.27±2.51V) is generated at 9.4 MΩ, and the maximum power is 268.9±13.4 μW. The electroacoustic conversion efficiency is 44.41%.