Resonant Pressure Sensor Based on 2D Non-Layered β-In_2S_3

Jiankai Zhu, Luming Wang, Song Wu, Junzhi Zhu, Zenghui Wang

Fundamental and Frontier Sciences, University of Electronic Science and Technology of China, Chengdu, China.

Email: zhujiankai@uestc.edu.cn; zenghui.wang@uestc.edu.cn

Two-dimensional (2D) non-layered materials, along with their unique surface properties, offer intriguing prospects for sensing applications. Here, we demonstrate 2D non-layered nanomechanical sensors based on β-In_2S_3, where the devices exhibit great pressure responsivity of 2328.38 Hz/Torr, high measurement sensitivity of 0.073 Torr, and reliable dynamic response with periods of 0.9 s. Our work paves the way towards future integrated sensors based on 2D non-layered materials.

Fig. 1a exhibits the resonance response of a β-In_2S_3 resonator (Fig. 1b) across the pressure range of 15 Torr to 700 Torr. Specifically, one clear trend is that the fundamental-mode resonance frequency increases with pressure, consistent with compressing-cavity stiffening effect[1]. Another clear trend is that the quality factor Q decreases as pressure increases, which suggests dominant air-damping effect[2]. To evaluate the measurement sensitivity of such pressure sensor, we track the resonance frequency using a closed-loop measurement setup for 100 seconds, and obtain an RMS fractional frequency shift of 171.32 Hz. Through dividing the RMS fractional frequency shift by the pressure responsivity (2328.38 Hz/Torr, calculated from data in Fig. 1a), we obtain a theoretical pressure sensitivity (defined as the air pressure fluctuation corresponding to the RMS frequency fluctuation) of 0.073 Torr. We further verify the dynamic response of the β-In_2S_3 nanomechanical sensor by varying the pressurizing period, and the measurement results are shown in Fig. 1d.

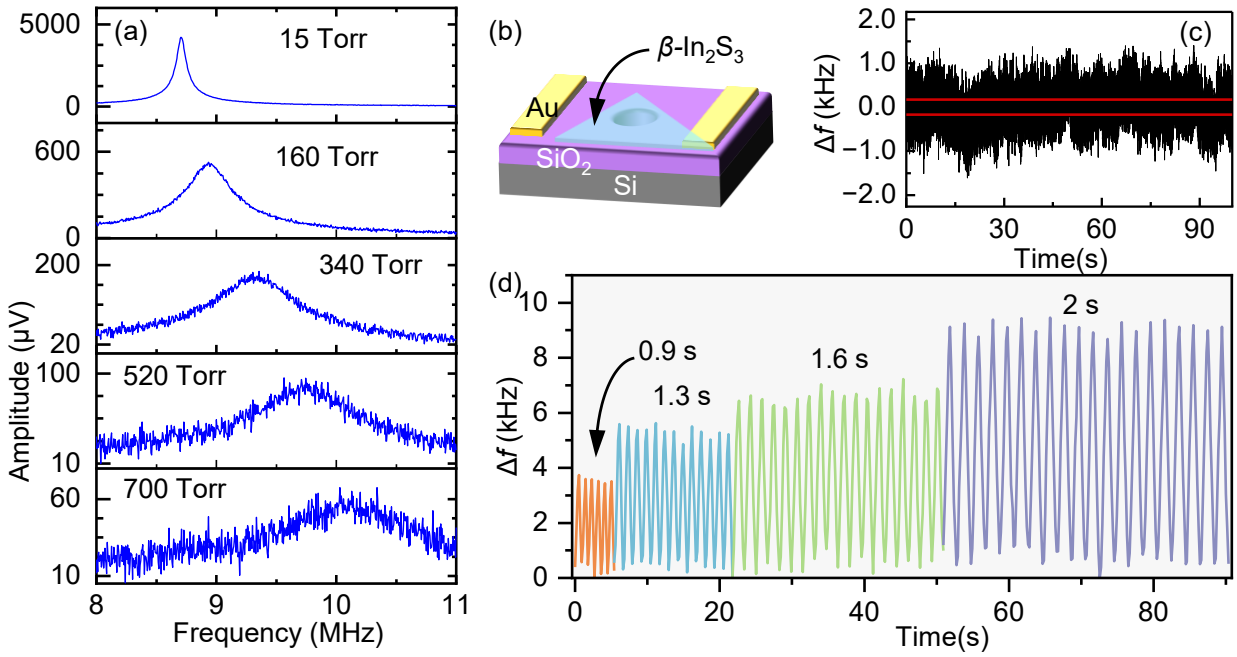

Fig. 1: (a) Resonant response under different pressures for the β-In_2S_3 resonator. (b) Schematic illustrations of the 2D β-In_2S_3 NEMS resonator. (c) Measurement of frequency stability. (d) Response of the β-In_2S_3 sensor to pressurizing cycles with different periods (and thus different terminal pressures).

[1] J. Lee, et al. Appl. Phys. Lett. 105, 023104, 2014.

[2] R. J. Dolleman, et al. Nano Lett. 21, 7617, 2021.