Table 1: Comparison of frequency stability measured from various state-of-the-art TPRs, showing frequency stability (Allan deviation) in this work being the best among all.

σ_A (τ)	f_0 [MHz]	Device & Material	Ref.
2.66×10^{-9} ($\tau\approx4.95$s)	6.759	Si TPR	This Work
89.07×10^{-9} ($\tau\approx1$s)	0.9292	Si TPR	[1]
85×10^{-9} ($\tau\approx0.8$s)	5.1	Si TPR	[2]
$^*40\times10^{-9}$ ($\tau\approx0.02$s)	0.9227	Si TPR	[3]

[1] A. Zope, *et al., Front. Mech. Eng.* **8**, 898668, (2022).

[2] T.-Y. Liu, *et al., 2017 19th Int. Conf. Sol.-State Sens., Actu. Microsys. (TRANSDUCERS)*, 452-455, (2017).

[3] H. Zhang, *et al., 2022 IEEE 25th Int. Conf. Micro. Electro. Mech. Sys. Conf. (MEMS)*, 142-145, (2022).

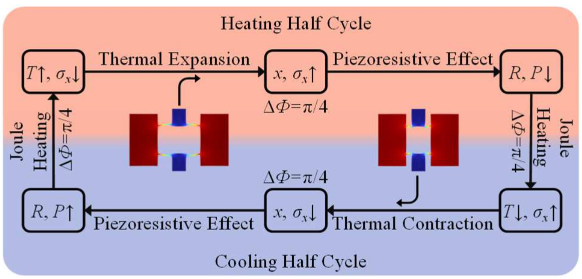

Figure 1: Thermal-piezoresistive feedback transduction block diagram describing how the TPR operates and illustrating the intrinsic internal feedback loop, depicting the changes in device temperature (T), actuator stress (σ_x), device displacement (x), actuator resistance (R), and actuator power (P), with their respective physical effect causing the changes in device parameters. Insets show maximum expansion (contraction) of the longitudinal mode shape when heating (cooling) occurs in the TPR.

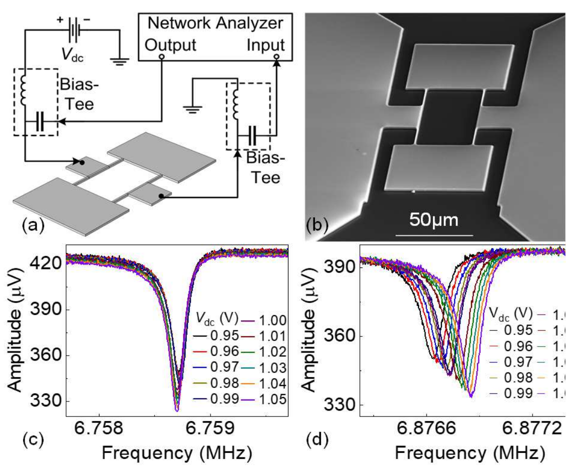

Figure 2: Electrical measurement of a single resonator and the measurement results. (a) Measurement circuit scheme for driving a single resonator and measuring its resonance response. (b) Scanning electron microscopy (SEM) image of the TPR with thickness t=2μm. (c) Measurement of resonance response for device A as V_{dc} is swept from 950mV to 1.05V. (d) Measurement of resonance response for device B as V_{dc} is swept from 950mV to 1.05V.

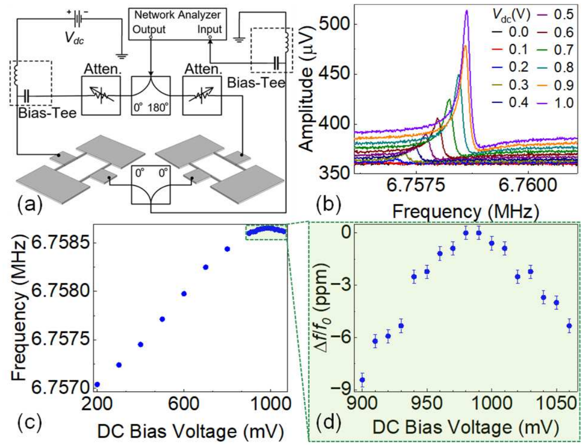

Figure 3: Electrical measurement scheme for a pair of resonators in a balanced-bridge circuit and measurement results. (a) Measurement circuit scheme for driving a single TPR (device A) at resonance while subtracting the background noise by driving a second device 180° out of phase. (b) Frequency response of bridged circuit as V_{dc} is swept from 0mV to 1V. (c) Resonance shift V_{dc} is swept from 0mV to 1.06V. (d) Zoomed-in plot of (c) from 900mV to 1.06V plotted in ppm.

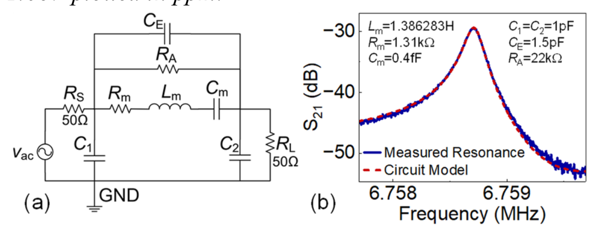

Figure 4: Equivalent circuit model and simulation results for balanced-bridge configuration of a pair of TPRs. (a) Equivalent circuit model for balanced-bridge circuit in Fig. 3a. (b) Comparison of equivalent circuit simulation and experimental results (V_{dc}=980mV), with exact values used for circuit components to generate the plotted resonance shown inside the plot.

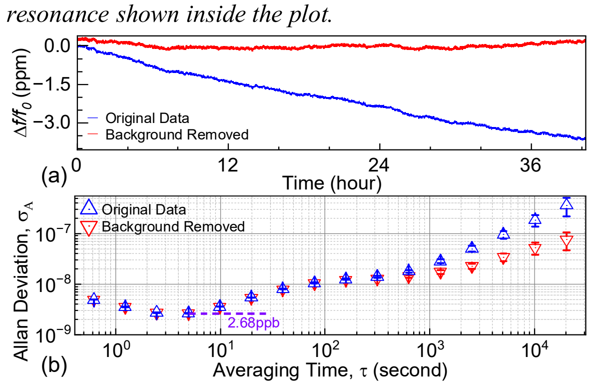

Figure 5: Resonance frequency tracking results from 40-hour PLL and calculated Allan deviation. (a) Measurement results from 40-hour PLL tracking resonance frequency of bridged device with (red) and without (blue) linear long-term frequency shift subtracted. (b) Allan deviation versus averaging time calculated from PLL data, showing a minimum Allan deviation of 2.68ppb for original data (blue) and a lower Allan deviation at longer averaging times with the linear frequency shift subtracted (red).