Docket #: S23-006

Ring electrode design for spurious suppression in piezoelectric resonators

Researchers in the Stanford University Power Electronics Research Lab developed an effective ring electrode that removes spurious modes in piezoelectric resonators. Spurious modes, secondary resonances in a bulk acoustic material, disrupt efficient piezoelectric-based power converter operation and worsen performance of other piezoelectric resonator applications, such as RF filters. By introducing a metallized, concentric ring, separated from the active electrode by a thin gap, the boundary conditions for supporting spurious lateral modes are changed such that these modes experience zero coupling coefficient and are not supported. (See comparison with reference designs in figure 1.) The SUPER Lab bulk lithium niobate acoustic resonator design is the first method that removes spurious modes in piezoelectric resonators tailored for power electronics and telecommunications applications like acoustic filters, oscillators, and transformers.

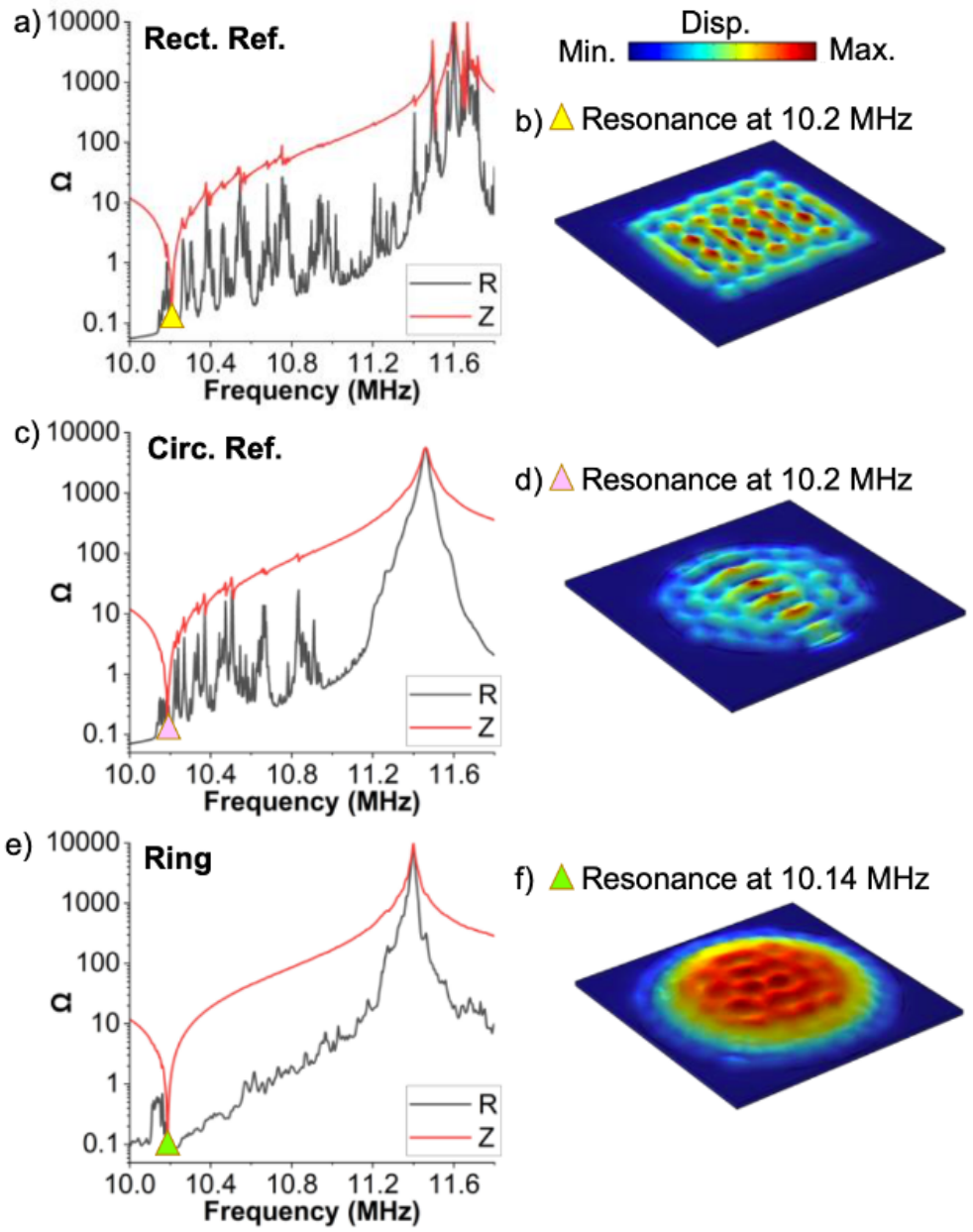


Image courtesy the SUPER Lab

Figure 1 Simulated impedances (Z) and resistances (R) of the rectangular reference design (a), the circular reference design (c), and the novel grounded ring design (e). Displacement at resonance of all three designs, marked by triangles in the impedance plots, are illustrated in (b, d, f).

Stage of Development – Prototype

The SUPER Lab working prototype achieved a high Q of 4000, k_t^2 of 30%, and a large fractional suppressed region of 62%. Research continues to extend the design to applications like filters, oscillators, and transformers .

Applications

- Power electronics - piezoelectric power converters
- Telecommunications - acoustic filters

Advantages

- Improved efficiency and performance - high Q of 4000, k_t^2 of 30%, and a large fractional suppressed region of 62%.
- First method that removes spurious modes in piezoelectric resonators tailored for power electronics.

Publications

- E. Stolt, W. Braun, K. Nguyen, V. Chulukhadze, R. Lu and J. Rivas-Davila, "A Spurious-Free Piezoelectric Resonator Based 3.2 kW DC–DC Converter for EV On-Board Chargers," in *IEEE Transactions on Power Electronics,* vol. 39, no. 2, pp. 2478-2488, Feb. 2024
- Nguyen, K., Stolt, E., Braun, W., Chulukhadze, V., Segovia-Fernandez, J., Chakraborty, S., Rivas-Davila, J., & Lu, R. (2023). Spurious-Free Lithium Niobate Bulk Acoustic Resonator for Piezoelectric Power Conversion. *arXiv preprint arXiv:2308.13902.*

Patents

- Published Application: 20240348228
- Issued: 12,665,565 (USA)

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