

[Supplementary Material]

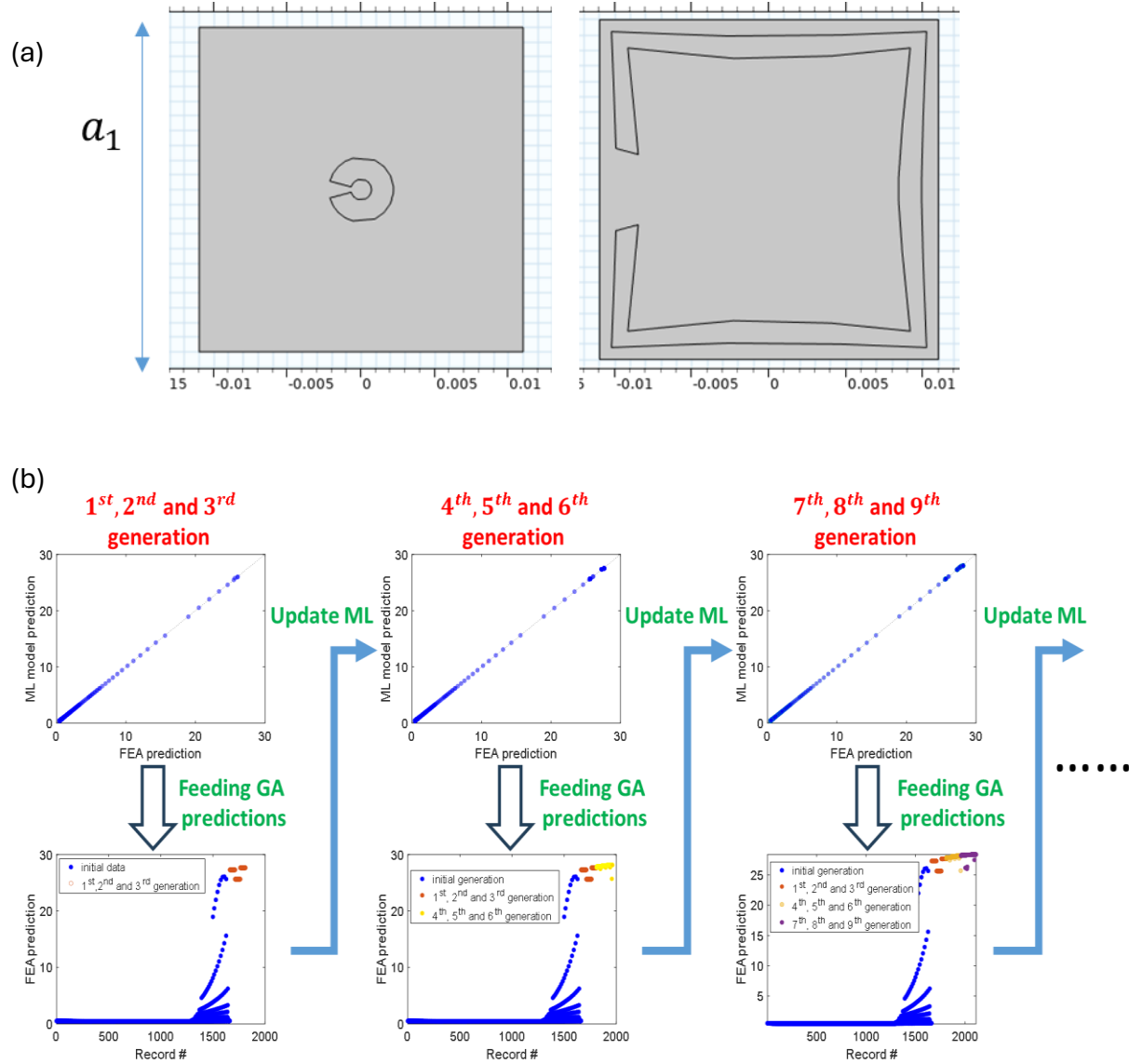


Figure S1.(a) Cavity shapes possible with formulation.(b)Output prediction by machine learning model at different generations with updating.

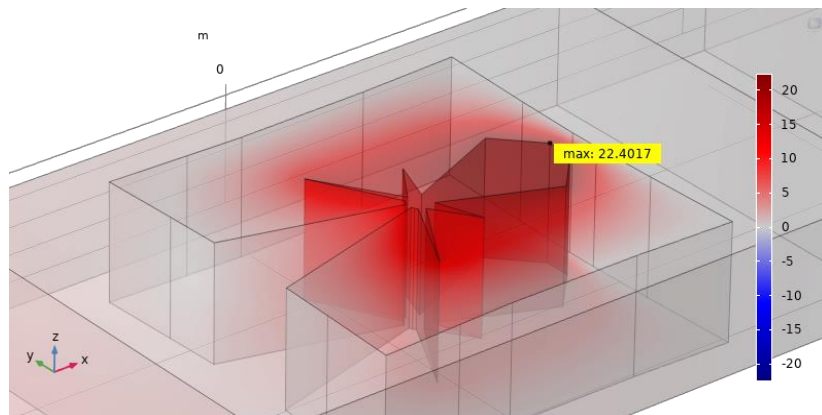


Figure S2. Simulation of 2.5D cavity design

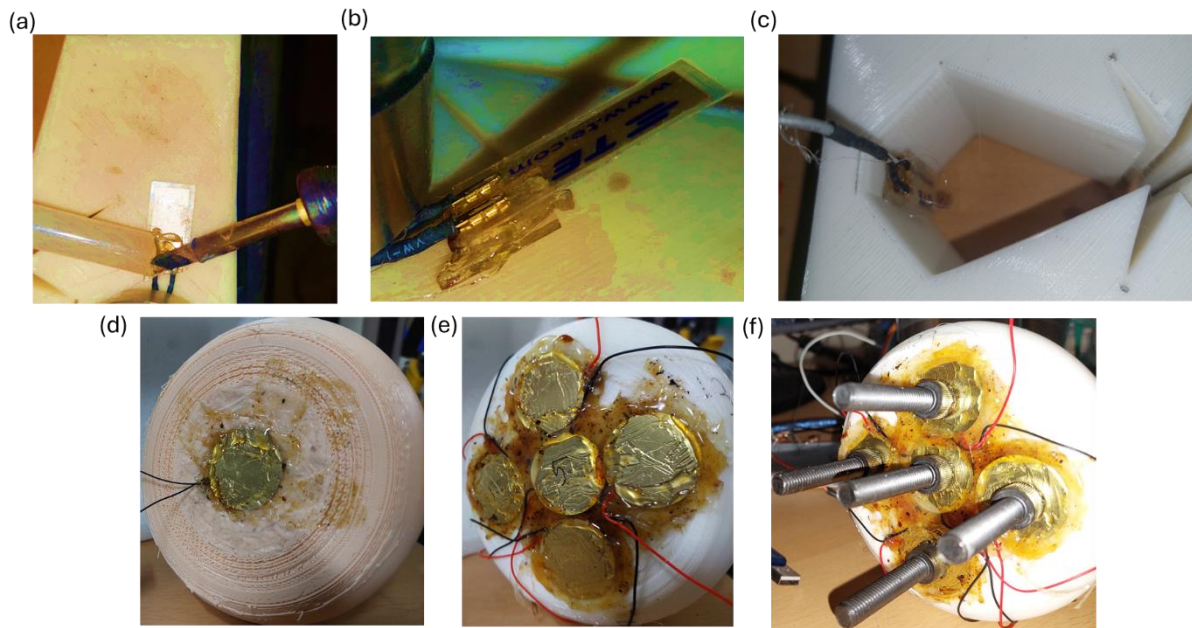


Figure S3. Photos for the attached piezoelectric materials on the designed metamaterial cavity. (a-c) PVDF bonding with 2.5D cavity. (d-f) Shows sealing of PZT disc and weights.

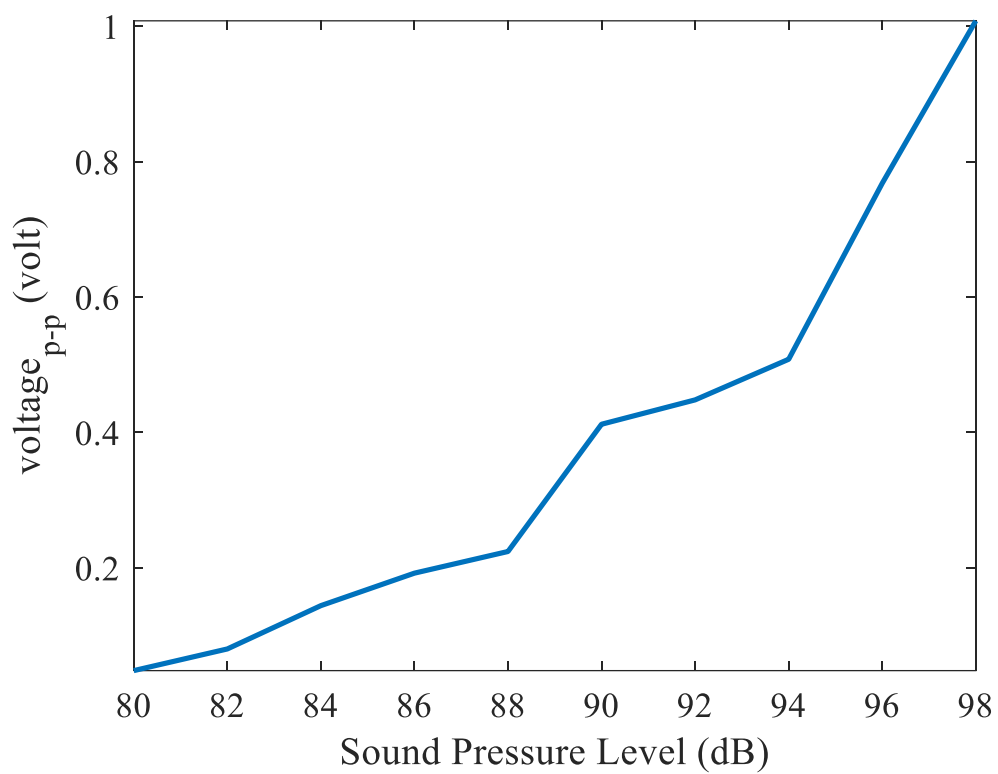


Figure S4. Experimental voltage measured from the five-PZT stack at different SPL values.

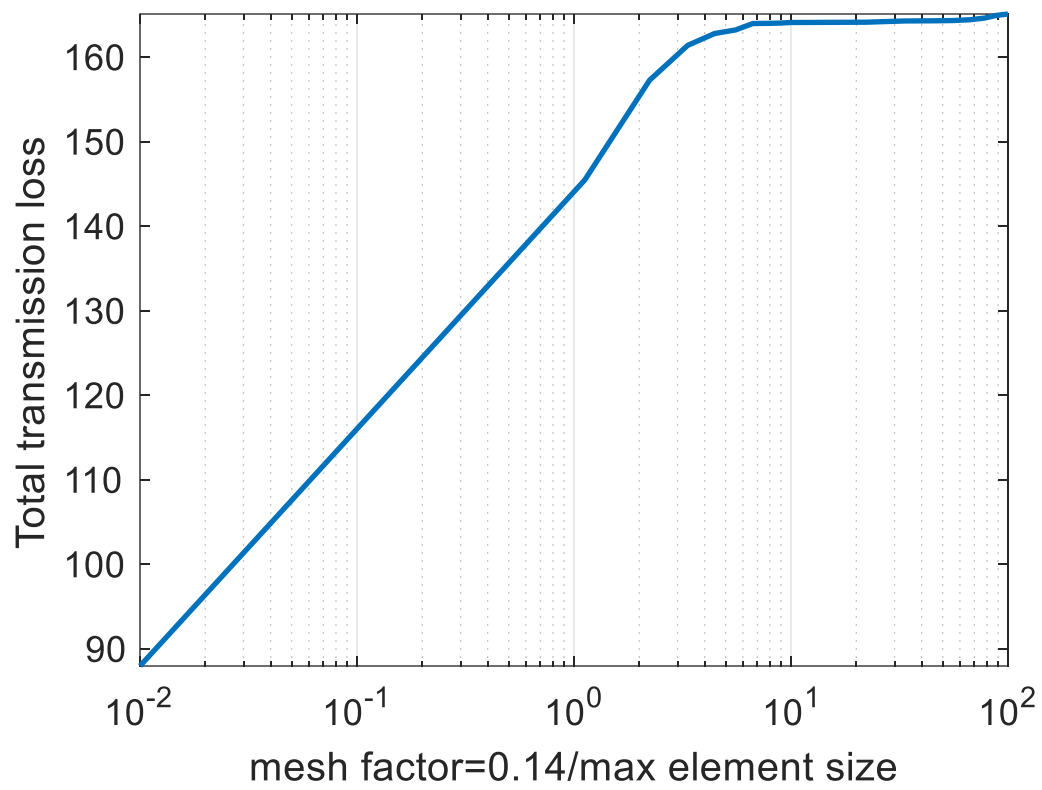


Figure S5. Mesh convergence analysis showing the variation in the simulated pressure amplification factor with maximum element size. A maximum element size of 1 mm was selected for the final simulations because further mesh refinement produced negligible changes in the calculated response.

Table S1. Piezoelectric and physical properties of PZT-5H circular plate

Parameter	Value
Brass Radius	13mm
PZT radius	10mm
Poission ratio	0.23
Thickness	0.2mm
Density	$7500kg/m^3$