SAWtrain Research Highlight 8: "Pressure sensing with zero group velocity Lamb modes in self-supported a-SiC/c-ZnO membranes"

The propagation of the Lamb modes along a-SiC/c-ZnO thin supported composite structures was simulated for different ZnO and a-SiC layer thicknesses and electrical boundary conditions. Zero group velocity (ZGV) points were identified where group velocity vanishes while the phase velocity remains finite, at specific layers thickness values. ZGV resonators (ZGVRs) were designed that consist of only one interdigital transducer (IDT) and no grating reflectors on its sides. In this work, the author studied the ZGV resonant conditions in the a-SiC/c-ZnO composite plate and the potential application for pressure sensing

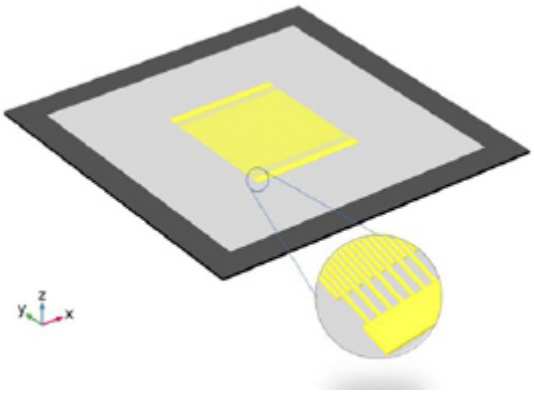

Figure 1: The schematic of the suspended membrane: the silicon frame is black, the membrane is gray; the IDT is yellow.

The finite element method analysis was performed to investigate the strain, stress and internal pressure the a-SiC/ZnO plate experiences when subjected to an external uniform differential pressure in the 1–10 kPa range. The contributions to the pressure sensitivity of the ZGVRs due to the dependence on the pressure of the elastic constants, the lateral and vertical strains were studied. 2D and 3D FEM COMSOL Multiphysics analysis was performed to determine the pressure sensitivity of the ZGVR by two-step simulations: (1) 3D stationary study of the mechanical deflection of the membrane with symmetric boundary conditions, under uniform differential pressure; (2) 2D eigenfrequency study of a single pair of IDTs at the total plate thickness to wavelength (H/λ) ratio corresponding to the ZGV2, with continuity boundary conditions.

The ZGVR pressure sensitivity, i.e. the relative frequency shift per unit pressure change, was found to be mostly affected by the change in the membrane thickness induced by the pressure. A pressure sensitivity of 9 ppm kPa−1, in the 4–10 kPa range, was predicted for the a-SiC(1 µm)/ZnO(1 µm) ZGV-based pressure sensor. The feasibility of high-frequency micro-pressure sensors based on a-SiC and ZnO thin film technology was demonstrated by the present simulation study.

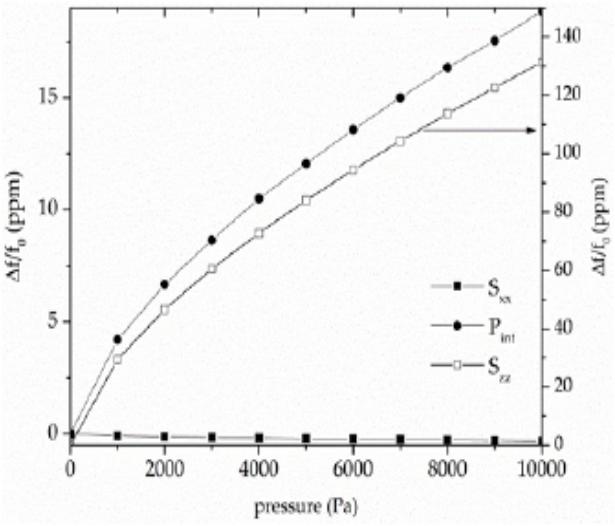

Figure 2: The $\overline{S_{xx}}$, $\overline{S_{zz}}$, $\overline{P_{int}}$ -induced ZGVR relative frequency changes versus the applied differential pressure for the 1–1 composite plate.

Publication:

Caliendo, C., and M. Hamidullah. "Pressure sensing with Zero Group Velocity Lamb modes in self-supported a-SiC/c-ZnO membranes." *Journal of Physics D: Applied Physics* 51.38 (2018): 385102.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642688.