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The International Debate on a Novel Lamb Wave Device Design Enabling Adjustable Phase by Applying an Analog-Voltage-Controlled Stress on Piezoelectric Film

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The lamb wave (LW) based MEMS, have an important potential to use in new generation high-frequency filters, oscillators, and sensor designs. We proposed a novel-lamb wave device design enabling the phase control of a narrow-band filter. The structure contains a 2-port LW device fabricated using aluminum-nitride thin-film. A capacitive transducer (CT) is mounted to the cavity under the film to apply mechanical stress to the film. The stress applied to the film results in a phase velocity change in the LW traveling through the film. The design is the first LW device with a controllable phase.

We analyzed the physical structure and the parameters, and the fabrication method to used is also presented. The COMSOL Multiphysics simulation program is used for the proof of concept. We have tested an LW-device that has 200nm AlN-film and two IDT structures that can excite acoustic waves with 100MHz center frequency. A CT is placed under the film with 1µm distance between its plates. The relation between the voltage applied to the CT, and the stress vs LW phase difference relation is investigated.

The simulation shows that 1.2882-1.2993 radian phase shifts are provided by using 0-34.6 kPa applied stresses respectively while the response is almost linear. These stress values can be provided by voltages applied to CT between 0-50 V respectively while the response is almost quadratic. The wafer bonding technique is used to form the cavity and CT structure. The AlN film on one side is formed by sputtering and wet Si etching.

Biography

Salih Çolakoğlu received his BSc degree in Yıldız Teknik University at Electronics & Communications Engineering between 2008-2014, and currently, he continues to his education in Marmara University Electrical and Electronics Engineering as a graduate student. Since October 2018, he was joined to Acoustic-MEMS group at the Marmara University and mainly focused on the high-frequency shear horizontal/lamb acoustic plate wave devices and their MEMS applications. His research interests are in RF MEMS Resonators and Micromachining Process, Acoustic Plate Waves, Micro and Nanofabrication, Biomedical Instrumentations.

Alper Sisman received the B.S. degree in 1998 from the Istanbul Technical University, Turkey; the M.S. and Ph.D. degrees are from Isik University in 2002 and 2010 all in electrical engineering. In 2011, he was a post doc at the Acoustic Transducers Lab., University of South Florida, Tampa, FL. Currently he is an Assistant Professor at the Electrical and Electronics Engineering Department, in Marmara University, Istanbul, Turkey.

His research interests include mixed signal processing, medical ultrasonic imaging and MEMS sensors/actuators.

Bedir Halcı graduated from Kırklareli Science High School in 2016, and currently enrolled in BEng degree education in progress with Electrical and Electronics Engineering at the Faculty of Engineering with Double Major (BSc degree) in Physics at the Marmara University. Since July 2019, he has been working with Assistant Professor Alper ŞİŞMAN at the Marmara University, and mainly focused on the high-frequency shear horizontal or lamb acoustic plate wave devices and their MEMS applications.

His research interests are in Theoretical Physics, Modelling & Simulation of Multiphysical Systems, Energy Harvesting and Surface Acoustic Waves.

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