Finite Element Simulation of a Surface Acoustic Wave Driven Linear Motor

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Abstract

ABSTRACT
The paper presents finite element simulation of a surface acoustic wave (SAW) linear motor. The function of SAW linear motor depends on the principle of friction drive provided by SAW propagating on a piezoelectric substrate. The SAW motor consists of a slider driven by Rayleigh wave generated on a piezoelectric stator using an interdigital transducer (IDT) fabricated on the stator. In the simulation, a lithium niobate piezoelectric substrate is used as the stator on which aluminum IDTs are fabricated at the two edges and a cuboid slider is placed in the path of SAW propagation with preload. The characteristics such as displacement, velocity, contact pressure and forces acting on the slider for sine wave excitation are studied. The slider in the SAW motor can move in both forward and reverse directions and the motor attains a velocity of 0.3 m/s with the continuous wave excitation.

INTRODUCTION
Use of piezoelectric materials has facilitated miniaturization of motors, and several mechanisms to construct ultrasonic motors have been reported [1], [2], [3]. The advent of surface acoustic wave (SAW) motors led to improved resolution and high-power-density operation [4], [5]. Persistent development in SAW motors resulted in light-weight, very high speed, and feasibility of sub-nanometer stepping resolution [6], [7]. The motor is consists of a slider of cubical shape, which is tightly placed on the active region of the delay line SAW device. A 128o rotated Y cut X propagated lithium niobate (LiNbO3) or (LN) substrate is used as stator where aluminum (Al) electrodes are fabricated in the shape of comb structure called as interdigital transducers (IDTs) at both side ends as shown in Figure 1 [8],[9]. A Rayleigh wave is generated and propagated on the surface of the stator when a RF power is applied to the IDTs [10].
USE OF COMSOL MULTIPHYSICS
The Piezoelectric Devices physics in COMSOL Multiphysics software is used for the simulation of the SAW motor. The FE simulation is performed in 3D plane geometry.
SAW motor model
When preload is applied from the top of the slider, slider makes a tight contact with the stator. As the generated Rayleigh SAW wave passes under the slider, it makes a frictional contact to the bottom surface of the slider and moves it in the reverse direction of propagation of SAW as shown in Figure 2.
RESULTS
Continuous wave excitation results in the translational displacement of the slider of 10 nm during

initial 1.5 μs as shown in Figure 3.
The plot for the velocity of the slider shown in Figure 4 indicates step change in motion for every cycle of the excitation. The velocity stabilizes to 0.3 m/s after the application of continuous wave excitation for about 1 s.

CONCLUSIONS

A SAW motor with LN stator and silicon slider is simulated in COMSOL Multiphysics. Initially the slider moves in steps and attains a velocity of 0.3 m/s with the application of continuous RF power.

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Figures used in the abstract

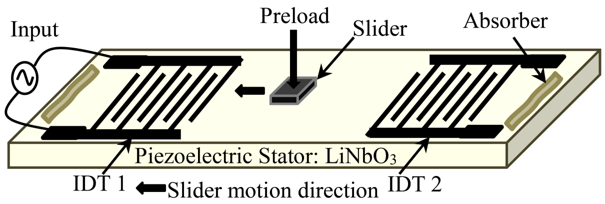

Figure 1: Piezoelectric SAW Motor.

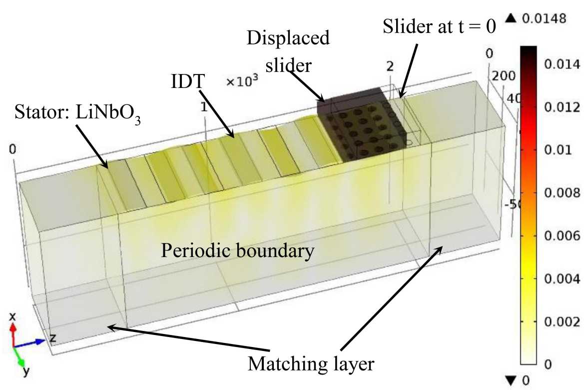

Figure 2: Displacement Profile Showing Surface Vibrations and Slider Movement.

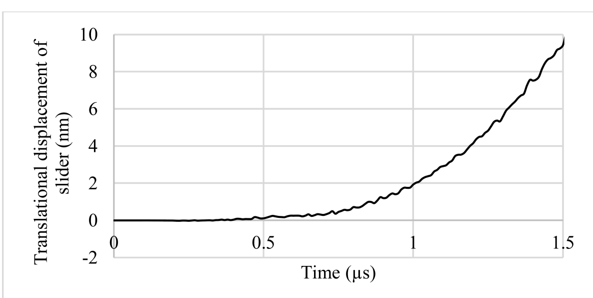

Figure 3: Translational Motion of the Slider.

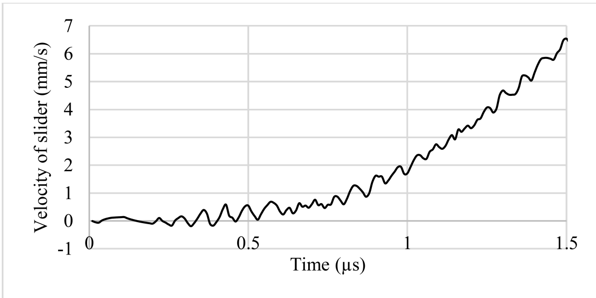

Figure 4: Velocity of the Slider.