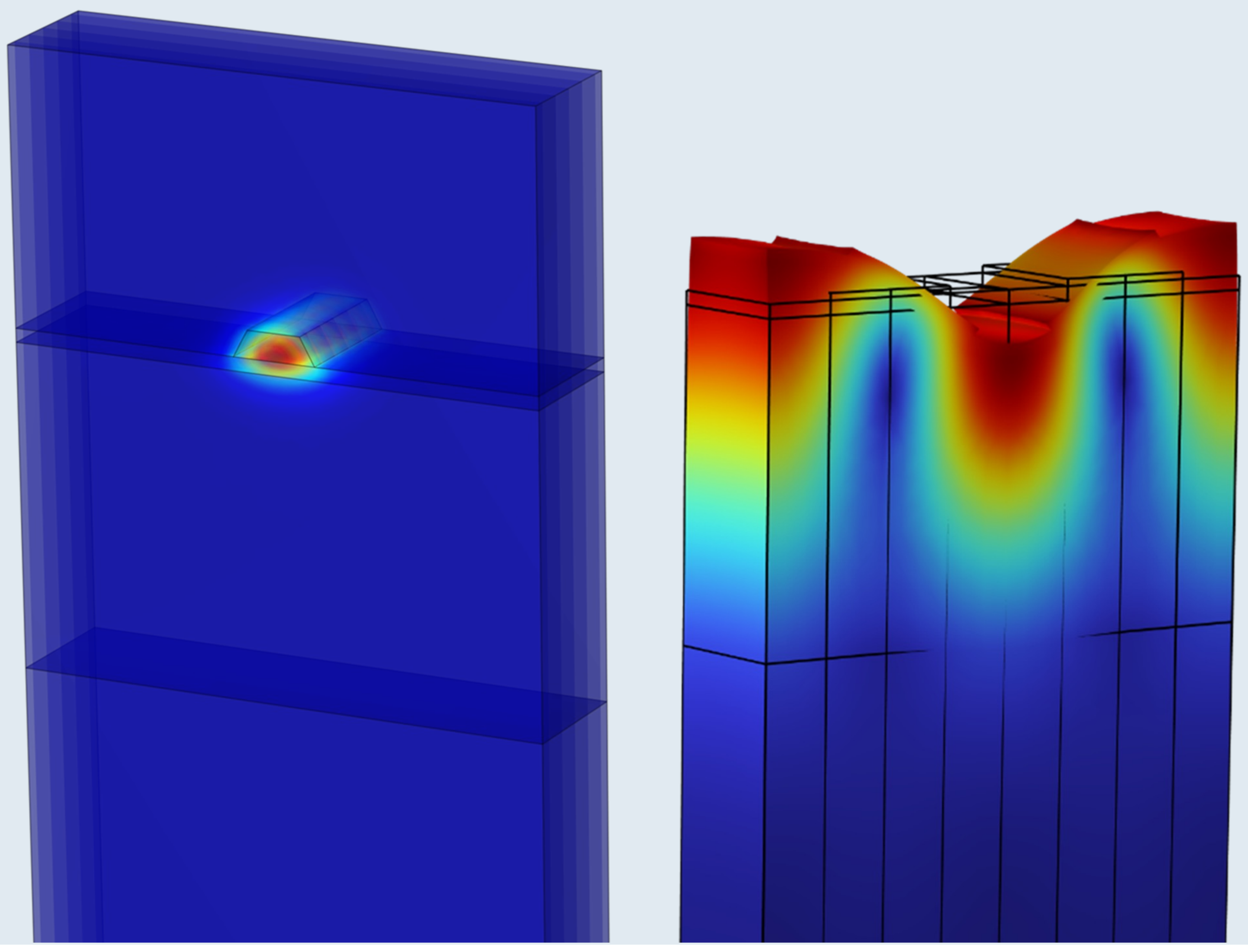

Simulation of Acousto-Optic Modulation on Thin Film Lithium Niobate on Insulator platform

Modeling the interaction between surface acoustic and optical modes on thin film lithium niobate on insulator (TFLN) through the photoelasticity effect using an equation-based approach.

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Introduction

Acousto-optic modulator (AOM) is an important optical component functioning as phase modulation, frequency modulation, and filters in optical networks, for internet of things (IOT), 5G/6G technology, and quantum computation systems. Thin-film LNOI (TFLN) is a highly promising material for this application, offering low-loss propagation for both acoustic and optical modes. Its properties enable seamless integration of acoustic and optical devices within a single substrate [1].

AOM operates through the interaction of surface acoustic waves (SAWs) and optical modes via the photo-elastic effect. SAWs are electrically generated via piezoelectricity effect using interdigitated electrodes (IDTs) on top of TFLN [2]. This project focuses on the design and fabrication of an integrated AOM on the TFLN photonic integrated circuit (PIC) platform [3], with modeling efforts aimed at optimizing various parameters for increasing the efficiency while balancing cost and time.

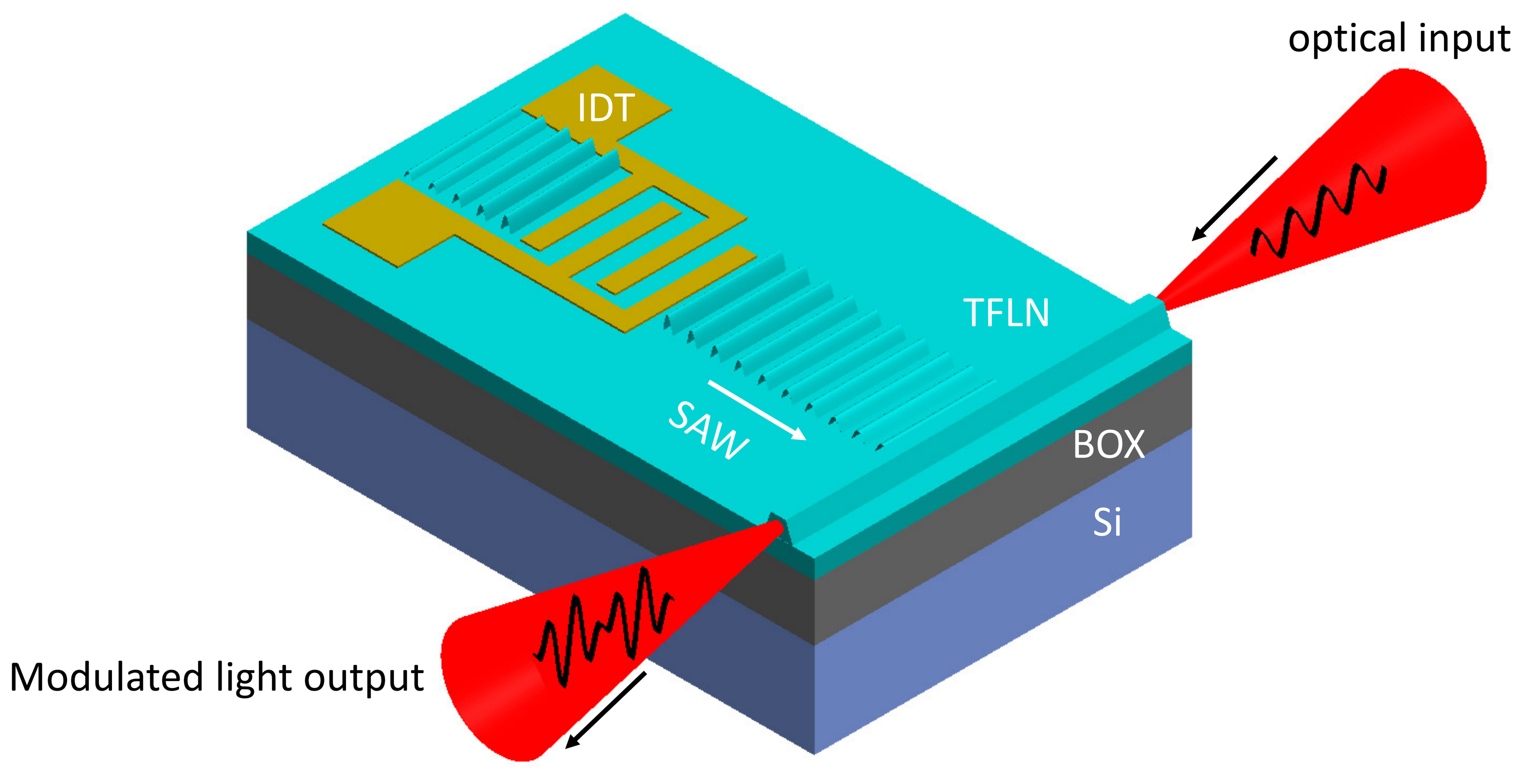

FIGURE 1. Schematic of acousto-optic modulator device.

Methodology

The simulation of AOM was performed using a 2D model, with depth (acoustic aperture) defined in the physics engine. Initially, the surface acoustic waves were modeled using Solid Mechanics (solid) and Electrostatics (es) interfaces, while the optical mode was simulated using Electromagnetic Waves, Frequency Domain (ewfd). Then the acousto-optic interaction was calculated by the expression [1]:

$$\Delta(n)_{EO,PE} = -\frac{\epsilon_0 n^5}{2}\frac{\iiint E^*(r_{ijk}\grave{E}_k + p_{ijkl}S_{kl})E\,dv}{\iiint < E|\epsilon|E > dv}$$

Where n is effective refractive index and E, r, È, P and S are optical wave electric field, electro-optic coefficient, electric field of acoustic wave, photoelasticity, and strain, respectively.

Results

The FEM simulation results shown in Fig. 2a, obtained from an acoustic resonator with an 8 µm wavelength, demonstrate the excitation of two primary Rayleigh acoustic waves at 400 MHz and 700 MHz, propagating in z direction on 200 nm X-cut TFLN, partially leaking into the silicon dioxide and silicon substrate. We have also fabricated the device, and the experimental data (Fig. 2b) strongly aligns with the simulation results. Additionally, the fundamental optical modes can propagate in our designed waveguide.

The key parameter for evaluating AOM phase modulation is the half-wave voltage-length, which in our model for optical TE mode is 1.83 V·cm. Further optimization of additional parameters is planned to reduce the half-wave voltage-length and improve AOM efficiency.

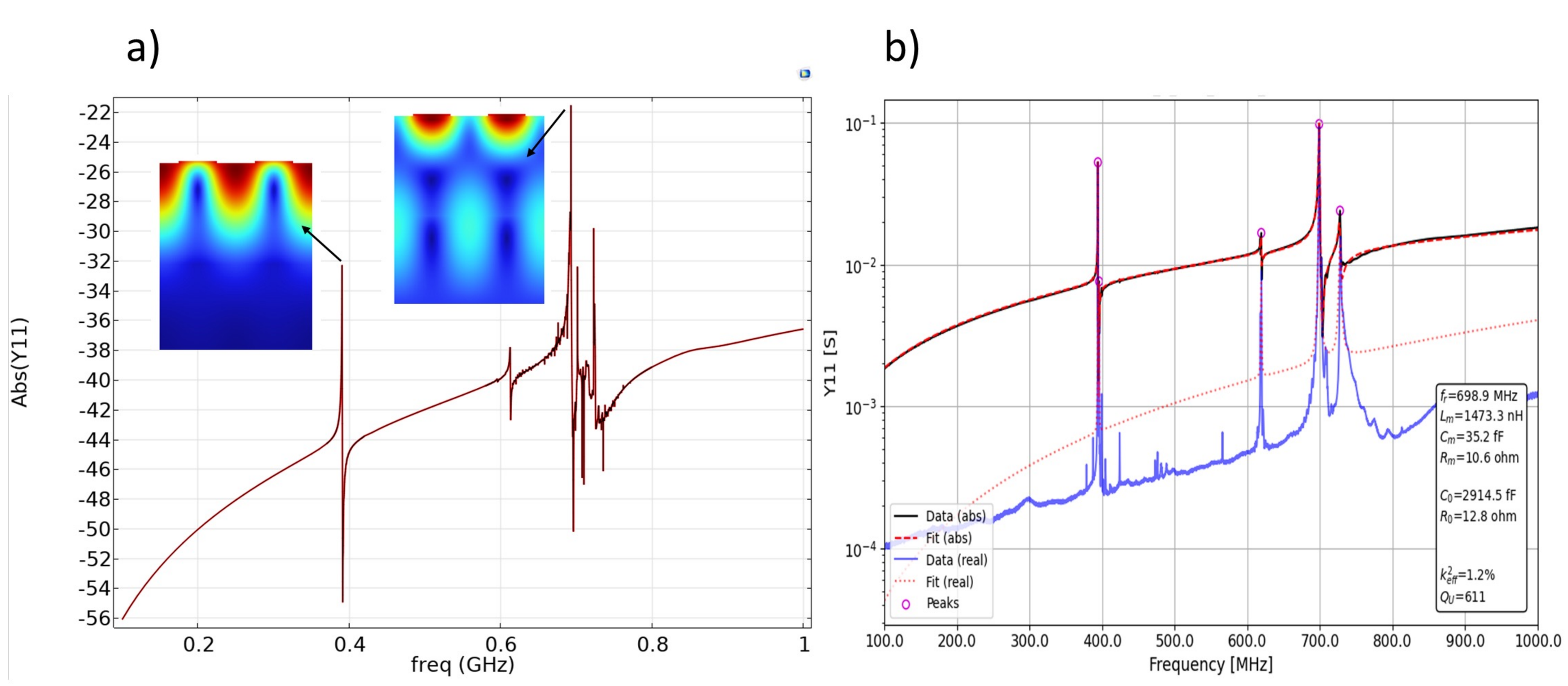

FIGURE 2. a) FEM simulation and b) experimental results of acoustic resonator with 8 µm wavelength.

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PATTERN

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