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Scalable Manufacturing of Lithium Tantalate on Insulator Modulators

Increasing data traffic in modern networks are putting new requirements on electro-optic interfaces exchanging information between electrical and optical signals. Such requirements include a compact footprint, scalable manufacturing, high actuation efficiency, and large bandwidths. Electro-optic modulators implemented in lithium niobate photonic integrated circuits (PICs) can readily verify such demands [1]. However, market constraints in conjunction with physical limitations, e.g., birefringence and photorefractive damage thresholds, potentially limit the deployment of this technology. Here, we provide an overview of recent developments in implementing PIC-based electro-optic modulators relying on lithium tantalate. This compound is a ferroelectric material closely related to lithium niobate while exhibiting similar electro-optic features and fewer limitations [2]. We rely on an argon plasma physical etch to pattern lithium tantalate PICs [1]. This wafer-scale process relies on a diamond like carbon hard mask providing an etch selectivity of roughly x3 for some ferroelectrics, thereby providing 600 nm thick integrated ridge waveguides with a 200 nm slab. With this geometry, we implement electro-optic modulators based on a 4um wide and 8 mm long waveguide. Electron-beam physical vapor deposition then adds gold electrodes separated by a 7um gap enclosing the waveguide. This configuration allows for a V_π L actuation voltage product of 3.17 V cm and a 3-dB modulation bandwidth of 75 GHz. We further improve these figures of merit by replacing the electrode material by lower-resistivity copper deposited with a Damascene process while optimizing the device's geometry to better match the velocities of the modulator's underlying optical and RF fields. With this configuration, we reduce the device's V_π L to 2.7 V cm and extend its bandwidth beyond 110 GHz [3].

References

[1] Z. Li et al., Nat. Commun. 14 (2023) 4854
[2] C. Wang et al., Nature 629 (2024) 784-790
[3] M. Lin et al., arXiv:2312.16746 (2025)

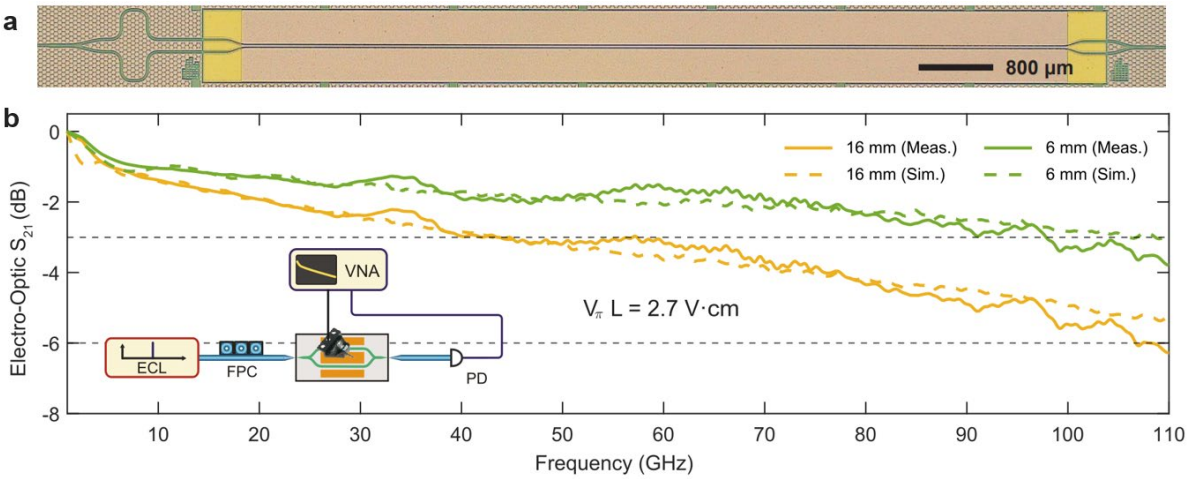

Figure 1: Lithium tantalate on insulator modulators. a, Optical micrograph of a 8 mm long modulator relying on copper electrodes. b, Small signal electro-optic response of the modulator shown in a, showing a 3-bandwiidth exceeding 110 GHz.