Title: High-Performance Electro-Optic Systems with Thin Film Lithium Niobate Photonic Platform

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Abstract *I will discuss recent progress on the development of high-speed and high performance electro-optic modulators and frequency comb sources realized in thin film lithium niobate photonic platform, that can operate across wide wavelength range.* ©2023 The Author(s)

The last two decades have seen tremendous progress in the field of integrated photonics, and chip-scale photonic systems can now be found everywhere! Optical communications systems (telecom and datacom) crucially rely on integrated photonics to transmit and receive the data over a wide range of wavelengths and distances [1-2]. A wide variety of commercial (5G, 6G) and defence microwave and millimetre wave communication systems (antenna remoting, satellite communications, etc) use photonics for filtering, amplification, interference suppression, channelization, up-/down-conversion, and more, leveraging the small form factor and high efficiency enabled by these chip-scale platforms [3]. Compact chip-scale spectrometers have found applications in optical coherence tomography (OCT) [4], while chip scale frequency combs are being utilized for precision measurements of time [5] and distance [6], and are indispensable for realization of the most precise optical clocks, ranging systems and spectrometers [7, 8]. Machine vision used in autonomous vehicles greatly benefits from chip-scale LIDARs [9] while photonic enabled accelerators are being used for high performance computing applications [10, 11]. Finally, integrated photonics is being used to realize quantum computers [12] and chip-scale quantum repeaters [13].

However, since many of these systems rely on silicon-photonic backbone, they are reaching their limits. This is particularly true for applications that require very large bandwidth (> 100 GHz), high linearity, very small loss passive (~ db/m) and active components, and operation over wide wavelength range that often includes visible, and near-visible wavelengths.

Thin film lithium niobate (TFLN) photonic platform [14] (Figure 1) has recently emerged as a promising solution and powerful alternative to silicon photonics. For example, my team has demonstrated that TFLN platform can feature ultra-low loss optical waveguides (0.03 dB/cm) and ultra-high-Q factor optical resonators (Q ~ 10^7) both at telecom [15] and visible wavelengths [16], as well as record-performance electro-optic (EO) modulators that can be operated directly from CMOS circuitry [17, 18]. By cascading EO modulators or combining them with optical resonators we were able to demonstrate time-lens based [19] and resonator based EO frequency combs [20, 21], respectively. EO photonic molecule [22] was also demonstrated and used to realize frequency domain shifters and beam splitters [23] as well as microwave-to-optical transducers [24[, of interest for quantum network applications. By combining TFLN modulators with THz antennae generation and detection of THz waves was also demonstrated [25]. Finally, lasers [26], combined with EO isolators [27], and detectors [28] have been integrated directly on TFLN platform.

In my talk I will discuss these results, recent advances in the field, as well as remaining challenges facing this exciting platform. Emerging applications in microwave and quantum photonics will be highlighted.

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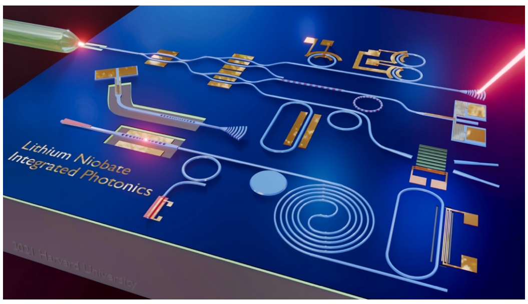

Fig. 1: Thin film lithium niobate photonic platform combines ultra-low loss passive optical components with high performance electro-optic and all-optical nonlinearities, and piezo-electricity.

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