Lithium Niobate on Insulator: Overcoming the Fabrication Challenges for Photonic Integration

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Abstract *Integrated photonics is becoming more and more multifunctional thanks to the recent availability of an established material, lithium niobate, as thin films. Here, we show how we overcame fabrication challenges to achieve integrated and free space devices such as electro-optic modulators and metasurfaces. ©2023 The Author(s)*

Introduction

The constant evolution of lithium niobate, from a bulk material already widely used in telecommunications to a thin film is opening many functional applications on chip. Thanks to two technological advances, thin film fabrication and nanolithography etching processes, lithium niobate is becoming a reliable platform for photonic integration from the ultraviolet to the mid-infrared [1].
As shown in Fig. 1, less than 1 μm^2 waveguide can be fabricated by electron-beam lithography in thin film lithium niobate, with much stronger light confinement than in waveguides generated by titanium in-diffusion or micromechanics [2].

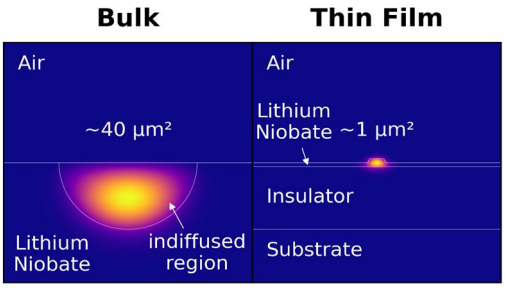

Figure 1. Cross-sections of waveguides for bulk (left) and thin film (right) lithium niobate with the propagating optical mode. The mode volume is reduced by one order of magnitude for ridge waveguides as compared to in-diffused waveguides. (Taken from [3])

Nanofabrication of photonic devices

We will present recent advances in the nanofabrication process flow. In particular, how we achieved redeposition-free inductively-coupled plasma etching of lithium niobate for integrated photonics [4]. Then, we will focus on building blocks recently developed in our group: monolithic electro-optic spectrometer and periodic poling on chip for frequency conversion (Figure 2).

Besides integrated photonics, thin film lithium niobate is also interesting for free space flat photonics applications such as electro-optic metasurfaces [5]. Metasurfaces are periodic 2-dimensional arrays of nanoresonators and can be scaled to an arbitrary size. We will present our recent results with nonlinear metasurfaces.

Conclusions

Classical integrated and flat photonic are not the only application field of lithium niobate thin films. Quantum technology is also looking for small footprints and can profit from lithium niobate-on-insulator for high dynamic range modulator for atom traps, or as entangled on-chip photon sources through spontaneous parametric down conversion [6].

Acknowledgements

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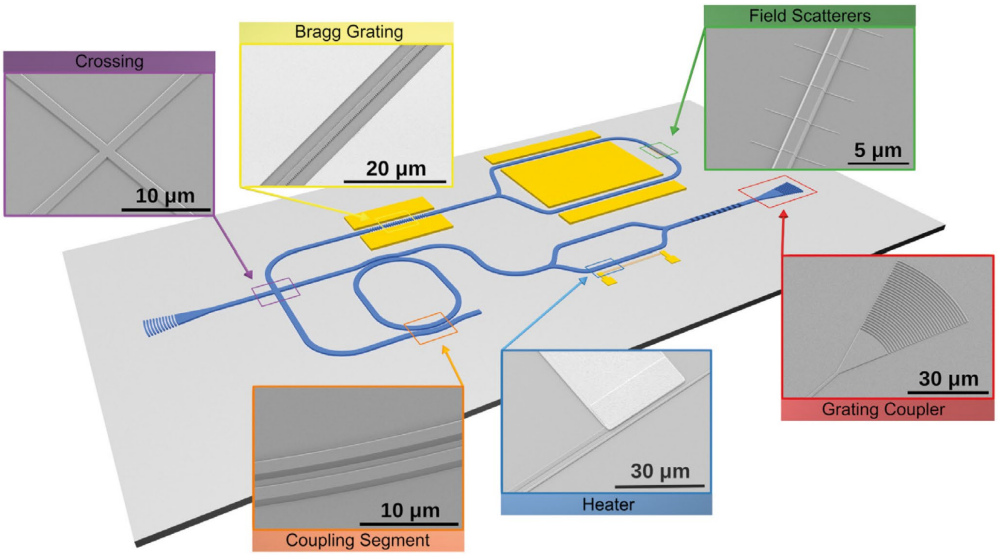

Figure 2. An example of lithium niobate-on-insulator photonic chip with various functionalities showing the fabrication capabilities with inset scanning electron microscope images. (Taken from [3])