Highly-Selective Etching of Micro-Transfer-Printed Thin-Film Lithium Niobate for Low Coupling Losses

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Abstract: Efficient low-loss coupling to micro-transfer-printed lithium niobate remains a challenge. We developed a highly-selective lithium niobate etch that enables selective etching of tapered coupling structures into the lithium niobate thin film after micro-transfer printing.

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Introduction

Micro-transfer printing of thin-film lithium niobate (LN) introduces high-speed modulation and efficient frequency conversion to the silicon photonics platform at a back-end level [1, 2]. For modulators, low insertion losses are desired, while for nonlinear and quantum processes, such as the generation of squeezed states, losses can be extremely detrimental. Therefore, efficient coupling to the printed lithium niobate slabs is crucial. Conventional LN etching is based on argon milling, but has very low selectivity due to the sputtering nature of the process. This makes it difficult to use on transfer-printed lithium niobate without damaging the exposed silicon photonics circuit underneath. In this work, we have developed a highly-selective wet etch that allows us to pattern tapered coupling structures into transfer-printed lithium niobate thin films.

Highly-selective lithium niobate etch

The developed wet etch consists of NH_4OH:H_2O_2 (1:4), which etches lithium niobate at an average rate of 10 nm/min at 85 °C. We measured a selectivity of 30 relative to SiO_2, implying that a 100 nm oxide hard mask is sufficient for fully-etched LN waveguides. In contrast, argon milling has a typical selectivity of 1 which makes the fabrication of fully-etched waveguides challenging. Due to the chemical nature of the etch, some anisotropy is observed, as seen in Figure 1a for x-cut LN. The RMS roughness after etching 300 nm LN is measured to be 0.33 nm (Figure 1b), which conforms with earlier reported propagation losses of 0.2 dB/cm and Q-factors of 10^6 [3, 4].

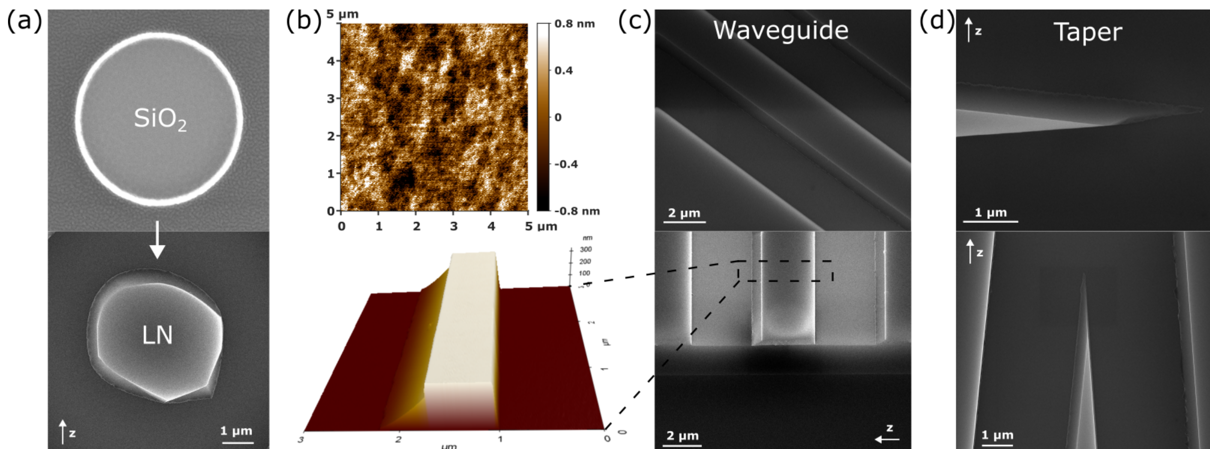

Fig. 1. (a) Anisotropy of LN etch: (top) SiO_2 hard mask, (bottom) resulting LN pattern, (b) AFM roughness measurement, (c) SEM and AFM images of patterned waveguides, (d) SEM images of patterned inverted tapers.