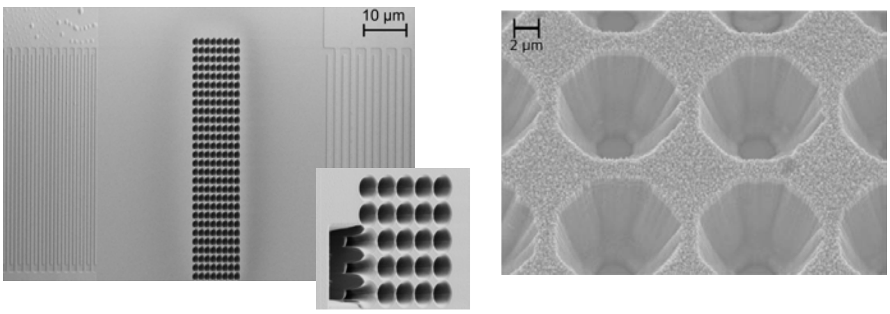
Structuring Lithium Niobate: Collective Etching and FIE Milling for Photonics and Phononics

Sarah Benchabane, Laurent Robert, Aurélie Lecestre, Gwenn Ulliac, Roland Salut and Vincent Laude
Institut FEMTO-ST, Université de Franche-Comté, CNRS, ENSMM, UTBM, 32 avenue de l'Observatoire, F-25 044 Besançon Cedex, Fra
sarah.benchabane@femto-st.fr

Abstract: In this paper, we discuss fabrication processes implemented for the realization of micron-sized and submicron-sized patterns in lithium niobate for application to nanophotonics or phononics. FIB milling as well as collective processes based on reactive ion etching in fluorine chemistries and their use for the fabrication of photonic and phononic crystal structures is illustrated. We will discuss the limitations of both methods and see how they can affect the actual physical performance of the fabricated devices.

OCIS codes: (160.3730) Lithium niobate; (350.4238) Nanophotonics and photonic crystals; (230.1040) Acousto-optical devices.

The remarkable physical properties of lithium niobate make this material a key element in a number of applicat ranging from integrated optoelectronics to radio-frequency acoustics. Its high nonlinear, electro-optical or acou optical coefficients, its piezoelectric properties, or the possibilities it offers in terms of waveguide fabrication a for the realization of both active and passive devices, many of them having successfully migrated from labora experiments to commercial and wide-scale applications. Further development on $LiNbO_3$ devices has for long l hindered by the lack of truly reliable and versatile techniques allowing surface machining of this material. Ind however well known and widely used lithium niobate might be, it remains to date a non conventional material f a microfabrication point of view. If a variety of wet and dry etching techniques has been reported in the literat none of the reported processes has really set itself as a standard. In particular, the etching of deep structures at submicron scale remains a challenging and critical technological step in the realization of a number of devi particularly in nanophotonics or phononics.



(a) (b)

Fig. 1: Phononic crystal made of air holes etched out of lithium niobate by FIB. The hole diameter is about 2 µm for a pitch of 2.2 µm. The hole depth is about 2.3 µm. The periodical structure is surrounded by two interdigital transducers acting as elastic wave emitters and receivers, respectively. (b) 10 µm pitch air/$LiNbO_3$ phononic crystal etched by reactive ion etching. The 9 µm diameter holes are 10.5 µm in depth.

In this work, we discuss fabrication processes implemented for the realization of micron-sized and submicron-s patterns in lithium niobate for application to nanophotonics or phononics. We will show that focused ion beam (I milling offers interesting possibilities for the patterning of submicron-sized structures. The limited yield of technological solution however calls for the implementation of collective processes with comparable etc capabilities. We therefore propose some possible alternatives based on reactive ion etching (RIE) in fluorine-ba chemistries. We will more precisely emphasize the current need for highly-selective etch masks with respec $LiNbO_3$ and we will propose some potential solutions based on the use of electroplated nickel. We will discuss limitations of both etching methods and see how they can affect the actual physical performance of the fabric photonic and phononic crystal devices.