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MICROSTRUCTURING LITHIUM NIOBATE: TOWARDS NEW HYBRID DEVICES

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Lithium niobate is among the most important nonlinear optical materials used today in the photonics industry as it combines a variety of very important properties which, apart from the optical nonlinearity, includes electrooptic, pyroelectric, piezoelectric behaviour and an optical transparency which extends from the UV (350 nm) to the infrared (5 μm) spectral region.

In order to benefit from both the optical and electro-mechanical properties of lithium niobate it is necessary to develop methods for the fabrication of suitable surface and/or bulk structures depending on the application involved. Such methods for surface and bulk microstructuring have been developed and are presented here aiming to show that there is significant scope for the broadening of the utility of this very useful material.

Firstly, engineering of ferroelectric domains and their subsequent differential etching in HF : HNO_3 acid mixtures provides a powerful tool for the fabrication of high aspect ratio structures such as cavities, channels, ridges and single crystal micro-tips[1]. This method when combined with advanced processing techniques, such as precision polishing and direct bonding, is able to produce free-standing three dimensional structures [2].

Recently developed ferroelectric domain inversion practices have enabled the fabrication of fine period (~1 μm) surface domain gratings [3]. Such fine period ferroelectric domain structures can be used either for first order quasi-phase-matched nonlinear and switchable electrooptic processes in waveguides or (after chemical etching) for the fabrication of fine period surface relief structures.

Secondly, the interaction of light with the material can modify the etchability of the surface in certain acids. Irradiation of undoped lithium niobate crystals with pulsed or continuous wave (c.w.) ultraviolet (UV) lasers modifies the etch rate of both +z and -z faces enabling the fabrication of relief patterns in a photolithographic manner [4].

Finally, a straightforward method for the fabrication of optical channel waveguides has been recently developed based on the direct-writing with intense c.w. UV laser radiation [5]. The advantage of such a direct writing method is that it is associated with a significant reduction of processing steps and that it can be applied on an already modified surface.

All these processing tools can be combined for the fabrication of a new generation of hybrid miniature devices which will benefit from both the optical (linear/nonlinear) and mechanical properties of lithium niobate. The devices which are proposed here are combining waveguide circuits fabricated on micro/nano structured surfaces to form expert or general purpose complex structures where material-light interactions can occur on the micro-scale. Such a general purpose device is schematically represented in figure 1.

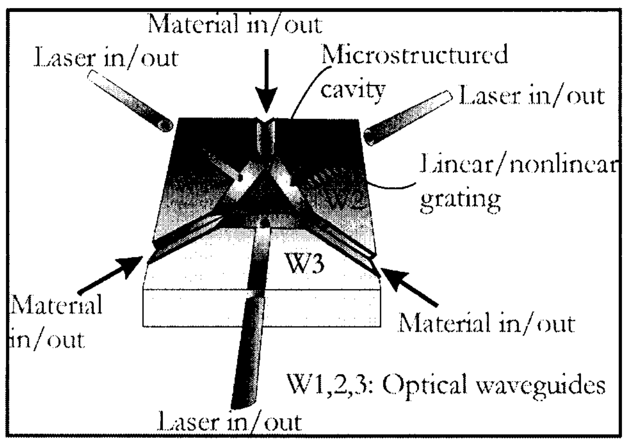

Figure 1. Schematic of a miniature multifunctional device based on combination of optical waveguide circuits and surface microstructures.

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