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Abstract: Using a modified Proton Exchange process we have realized Photonic Wires in X-cut $LiNbO_3$. They exhibit highly confined mode, low propagation losses, low strain induced polarization coupling and no reduction of the nonlinear properties. We are now transferring this technique to Z-cut $LiNbO_3$ in order to realize very efficient nonlinear devices in PPLN.

Introduction

Realizing photonic wires, in which the size of the mode is smaller or equal to the wavelength, in a nonlinear material is very attractive and the interest has already been exposed many times. Using a simple waveguide fabrication technique based on a special proton exchange process, we have been able to realize such photonic wires in X-cut $LiNbO_3$. They have been realized on 3" wafers and present highly confined modes (1.5x1.5 µm @ 1.5µm), low propagation losses, low strain induced polarization coupling and no reduction of the nonlinear properties. These waveguides are excellent candidates for realizing highly efficient electro-optic devices and present a very good adaptation to photonic crystals that are today realizable in lithium niobate[1], which opens the way to the realization of a completely new device family. In order to benefit of the same advantages to realize nonlinear devices we have extended this waveguide fabrication technique to Z-cut $LiNbO_3$ and we will present material and optical characterization of these.

Waveguide fabrication

In the early 80's when the Proton Exchange technique was presented for the first time[2] to fabricate waveguides in lithium niobate, it attracted a lot of interest because of its ability to produce a high increase (0.1) of the extraordinary index of the crystal, and therefore highly confining waveguides. But after a while, it appears that these waveguides were presenting a dramatic reduction of the electro-optic and nonlinear coefficient of the material. In all the efficient devices that have been reported using Proton Exchanged waveguides, the waveguides were presenting a low confinement ($\partial ne \leq 0.03$) and were identified as Annealed Proton Exchanged waveguides (APE) [[3] or Soft Proton Exchanged waveguides (SPE) [[4]]. Around 2000, it was reported that it was possible to obtain highly confining waveguides without damaging the nonlinear coefficient of the crystal using the Vapor Phase Exchange process (VPE) [[5]]. Unfortunately, this technique was very difficult to control and no device using it has been reported. Using another approach, we call HISoPE for High Index Soft Proton Exchange process, we have been able to solve this reproducibility problem and obtain waveguides presenting both high confinement ($\partial ne=0.1$), step index profiles, and preserved nonlinearities.

Nonlinearity measurement

We have investigated the influence of HiSoPE on the second order optical nonlinearity using reflected SHG measurements from the polished planar waveguide end face[[6]]. The results indicate that it is possible to realize highly confining waveguides on both X- and Z-cut wafers, without degradin the nonlinear properties of the material

Photonic wires fabrication and characterization.

The photonic wires were realized using a standard UV lithography process allowing fabricating strip waveguides with a width varying from 1 to 2 µm. The first waveguides were realized on X-cut wafers, and measurement performed on 25 mm waveguides cavities indicate that the propagation losses are in the order of 4dB/cm.

Acknowledgement :

The authors want to thank ANR for the financial support through project : ANR-09-NANO-004-01 phoXcry and CNRS Network CMDO+ for facilitation of the collaboration.

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