Proton Exchanged Waveguides on Congruent Lithium Tantalate and MgO-doped Lithium Tantalate

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Introduction: Lithium Tantalate (LT) has a shorter cut-off wavelength than Lithium Niobate (LN) which makes the material attractive for UV generation through nonlinear processes. While congruent LT (CLT) suffers strongly from photorefractive damage, MgO-doped LT (MgO:LT) is an interesting alternative as it was shown on LN that MgO reduces the photorefractive effects. On the other hand, fabricating highly confining, low-loss optical waveguides on LT while preserving its nonlinear properties is still an issue, as it was previously shown that the index variation obtained using proton exchange is one order of magnitude lower than that on LN and that direct Proton Exchange (PE) erases both nonlinear coefficient and periodic domains organization as on LN.

Proton Exchanged Planar Waveguides on CLT: A set of planar waveguides was fabricated on z-cut CLT samples from Crystal Tech and Roditi. As proton sources, we used benzoic acid (BA) melts buffered with amounts of lithium benzoate (LB) ρ_{LB}=m(LB)/(m(LB)+m(BA)) ranging from 0.5 to 3.5%. Based on our previous experience on LT [1], all the samples were processed at 330°C following the sealed ampules process. All samples are labelled CLTx.x, x.x referring to ρ_{LB}. The effective indices of the modes of the different waveguides have been measured using a two-prisms coupling technique in order to evaluate their propagation losses and to reconstruct their index profiles. On all the samples we tested, we were not able to observe scattering along the propagation, indicating that the propagation losses are low, typically lower than 1dB/cm according to our previous experience. The index reconstruction consists in using the IWKB method in order to evaluate the shape of the profile and the depth and δn_e of the different layers.

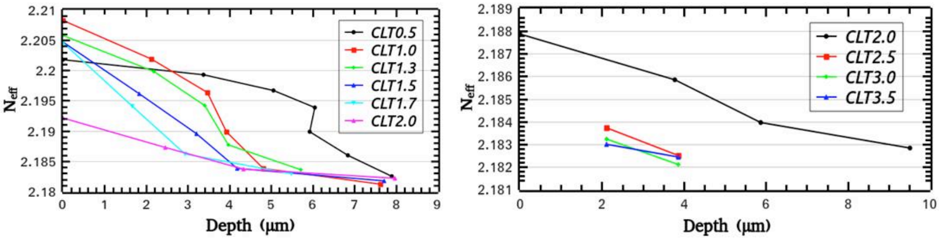

Fig. 1 Extraordinary refractive indices (@ 633nm) and calculated index profiles using IWKB for different ρLB. Waveguides were fabricated at 330°C and for 28hrs (left) and 72hrs (right).

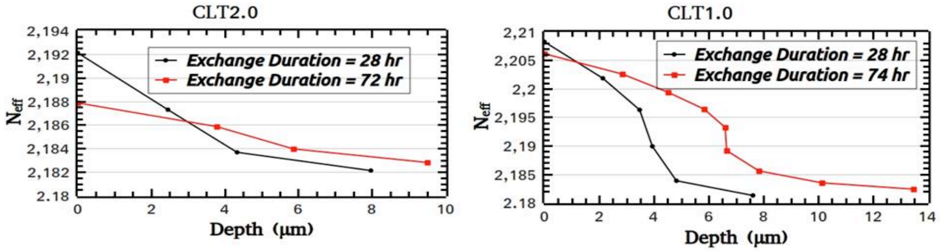

Fig. 2 Effect of the exchange time duration on the extraordinary refractive indices (@ 633nm) and calculated index profiles for 2% (left) and 1% (right) ρLB.

Figures 1 show the effective indices measured @ 633nm and the index profile for different ρ_{LB}. We note that for 2.5, 3.0 and 3.5% there are only two modes. According to [1] 3.5% should be SPE while those from 0.5 to 3.0% should be in the PE_{II} phase. The 2% seems particular as its surface index variation, while much larger than those obtained on SPE, is very different from the other PE_{II}. Figure 2 shows the effect of the exchange time duration on the index profile. While for CLT1.0, which exhibits a clear step-like profile near the surface, the depth is increased with time, CLT2.0 more likely seems to be annealed by the longer exchange duration. Focusing on ρ_{LB}=2%, the reproducibility was tested by fabricating three different samples in the same conditions and the measured effective indices were well in the measurements error bars. The local value of the second-order nonlinear coefficient was probed by SHG microscopy using the experimental set-up described in our previous works [2]. Figures 3 clearly show that 2% conserves the nonlinear coefficient in contrary to 1.7%. The 2% PE CLT planar waveguide more likely corresponds to the HiSoPE as already obtained on LN and is very attractive as it allows a relative good confinement while preserving the nonlinear properties [3].

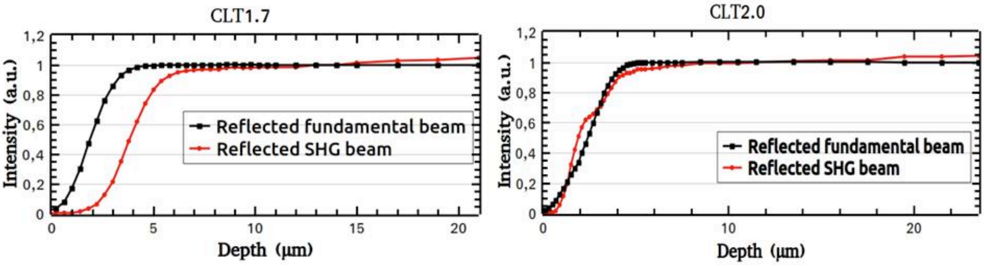

Fig. 3 Surface SHG for 1.7% (left) and 2% (right) ρ_{LB}. The superposition of SHG and IR signals (right) indicates that the nonlinear coefficient is preserved into the waveguide.

Proton Exchanged Channel Waveguides on CLT: Channel waveguides were processed using 2% LB for 28hrs at 330°C. At 1550nm, the resulting single-mode waveguides exhibit total insertion losses between two SMF28 fibres in a consistent 20 to 25% range. We also checked if hybrid modes were present or not and as expected no polarization conversion process was observed in contrary to LN [3] due to the positive birefringence of LT compared to the negative birefringence of LN. It thus seems that it is possible to obtain channel waveguides on CLT with good quality, good confinement and preserved nonlinear coefficient. We have now to study the effect of the PE process on poled CLT but we already started the study of PE exchanged planar waveguides on MgO:LT.

Proton Exchanged Planar Waveguides on 8% MgO:LT: We have started a similar study on 8% MgO:LT from Roditi. Figure 4 shows the effective indices measured @ 633nm and the index profile for ρ_{LB}=2% after 72hrs at 330°C. The comparison with Figure 2 indicates that MgO tends to slightly decrease the index variation. Similar results have been obtained for 1.0 and 1.5% and work is in progress to complete the study.

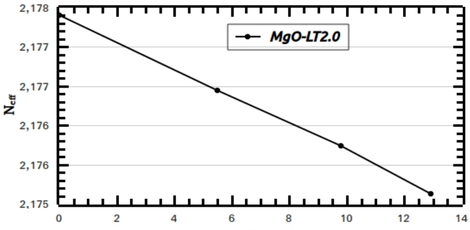

Fig. 4 Extraordinary refractive indices @ 633nm for ρ_{LB}=2% after 72hrs at 330°C.

References
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