GUIDES D'ONDES RÉALISÉS PAR ÉCHANGE PROTONIQUE SUR TANTALATE DE LITHIUM CONGRUENT ET SUR TANTALATE DE LITHIUM DOPÉ MGO

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Guides d'ondes réalisés par échange protonique sur Tantalate de Lithium congruent et sur Tantalate de Lithium dopé MgO

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Summary

We have studied the effects of proton source acidity and exchange duration at T=330°C. Surface SHG has shown that middle acidity is of great interest.

Mots-clefs : *planar waveguides; channel waveguides; proton exchange; Lithium Tantalate*

1. 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.

2. 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) $\rho_{LB} = m(LB) / (m(LB)+m(BA))$ 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.

Figures 1 show the effective indices measured at $\lambda = 633$nm 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}.

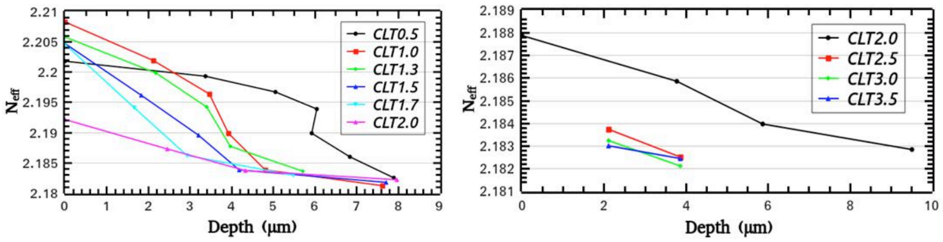

Fig. 1 : Extraordinary refractive indices (@ 633nm) and calculated index profiles using IWKB for different ρLB. Waveguides were fabricated at 330°C and for 28 hours (left) and 72 hours (right).

Figures 2 show 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 $\rho_{LB} = 2\%$, 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].

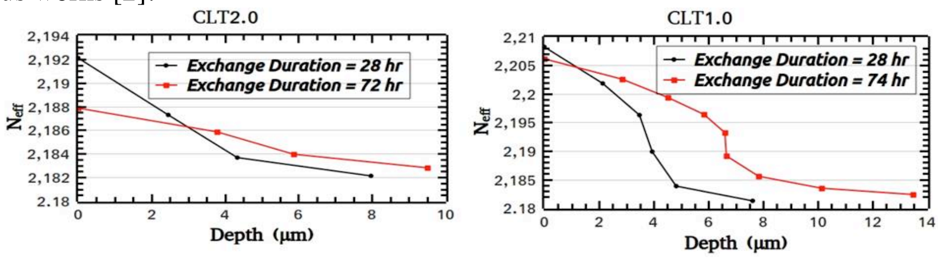

Fig. 2 : Effect of the exchange time duration on the extraordinary refractive indices (@ 633nm) and calculated index profiles for 2% (left) and 1% (right) ρLB.

Figures 3 clearly show that 2% conserves the $\chi^{(2)}$ 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].

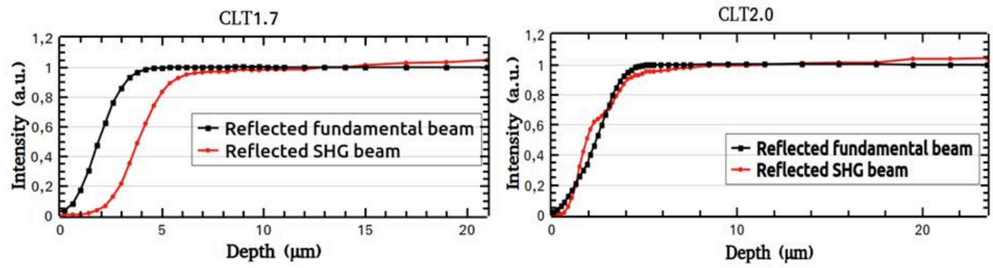

Fig. 3 : Surface SHG for 1.7% (left) and 2% (right) ρ_{LB}. The superposition of SHG and IR signals (right) indicates that the nonlinear coefficient is preserved into the waveguide.

3. PROTON EXCHANGED CHANNEL WAVEGUIDES ON CLT

Channel waveguides were processed using 2% LB for 28 hours at 330°C. At 1550 nm, 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 have already started the study of PE planar waveguides on MgO:LT.

4. 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 at 633nm and the index profile for ρ_{LB} ranging from 0.5% to 2.5% by step of 0.5% after 72hrs at 330°C. The comparison with Figures 1 and 2 indicates that MgO tends to slightly decrease the index variation. Work is in progress to complete the study.

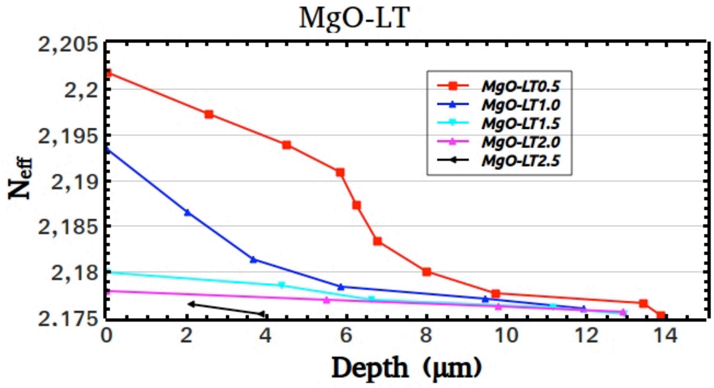

Fig. 4 : Extraordinary refractive indices at 633nm for ρ_{LB} = 0.5, 1.0, 1.5, 2.0 and 2.5% after 72 hours at 330°C.

Conclusion

We have studied Proton Exchange waveguides on Lithium Tantalate (LT) and MgO-doped LT (MgO:LT). An exchange temperature of 330°C has been fixed as it was previously shown to be a good trade-off between optical quality and reproducibility. As proton sources, we used benzoic acid (BA) melts buffered with amounts of lithium benzoate (LB) ρ_{LB} = m(LB) / (m(LB)+m(BA)). The acidity of the source of protons has been varied, leading to different types of index profiles (step, gradient and hybrid). The effect of the exchange duration has also been studied: for step-like waveguides the depth is increased with time while for gradient-like waveguides the index variation is decreased. A first comparison between LT and 8%Mg0:LT indicates that MgO tends to slightly decrease the index variation. Using surface SHG on LT we have shown that intermediate acid source (ρ_{LB} = 2%) should be an interesting candidate for fabricating good confinement optical waveguides while preserving the nonlinear properties of the original material. The same conclusion has to be confirmed on MgO:LT.

References

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