Cs^+ ion exchange channel waveguides on $RbTiOPO_4$

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***Abstract*—In this paper, RTP channel waveguides fabricated by the Cs^+ exchange method are presented for the first time. The losses were estimated being around 1.5 dB/cm. The Second Harmonic Generation was also demonstrated obtaining green conversion at 1133 nm.**

Keywords- $RbTiOPO_4$, Laser lithography, Cs^+exchange waveguides, Near Field Pattern, Second Harmonic Generation.

I. INTRODUCTION

The crystals of the $KTiOPO_4$ (KTP) family have an advantageous set of material properties that make them attractive as nonlinear optical elements in optical frequency conversion devices. Their high nonlinearity, high laser damage threshold, low photorefractive damage susceptibility and wide wavelength, angular and temperature acceptance bandwidth, make them particularly useful for short wavelength generation [1-5].

$RbTiOPO_4$ (RTP) is a crystal of the KTP family that presents an extra advantage in front of KTP. It can be doped with laser active ions with higher coefficient of distribution than KTP, with the possibility to obtain a self-frequency doubling (SFD) material.

In addition to the advantages mentioned above, recently, electric-field poling at room temperature of RTP was demonstrated [6]. Initial studies indicate that the effective nonlinearity in Periodical Poling RTP (PPRTP) crystals is comparable to that of PPKTP crystals.

For all of this, the study of the possibilities of Cs^+ ion exchange on RTP for creating waveguide channels is interesting. This study can be considered as the first step to optimize the Cs^+ ion exchange in RTP for future applications in integrated photonics.

II. CREATION OF CHANNELS

A. Ti channel pattern on the RTP substrate

The RTP crystals used for obtaining substrates were grown by the Top Seeded Solution Growth (TSSG) method. These

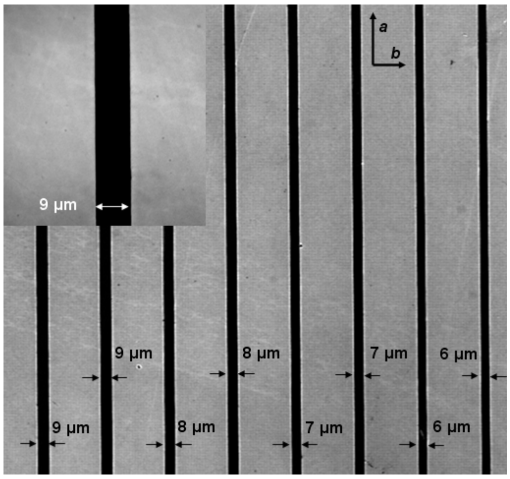

Figure 1. Ti channel patterns on a RTP substrate.

crystals were cut in plate-shape substrates perpendicular to the ***c*** crystallographic direction.

The Ti-mask pattern on the substrate was created in two steps. First, a glass mask was fabricated using a Heilderberg Instruments DWL 66 fs laser lithography equipment. After that, the fabricated mask was applied on the substrate using a MG 1410 mask aligner of conventional lithography.

For both steps the procedure was the same. First, a Ti RF-sputtering at 200 W was used, obtaining a film of 100 nm thickness. Then, a photoresist AZ 1505® (Microchemicals) was spin coated (thickness of 1 µm). After depositing the resist, the sample was UV exposed using one of both techniques mentioned above. Then, the resist was developed and etched using a selective mixture for Ti (H_2O_2 and NH_4OH). The Ti pattern obtained from lithography was formed by straight channels on the RTP substrate (see figure 1) in the range of 6 – 11 ± 0.2 µm of width.

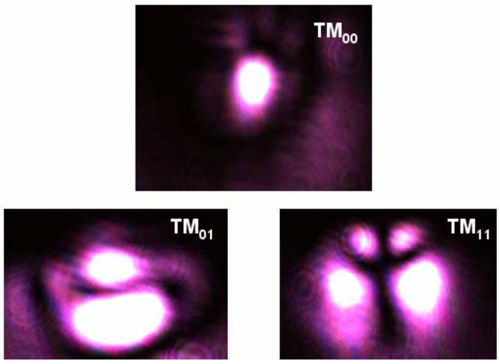

Figure 2. Near Field Pattern of the channel waveguide modes.

B. Cs^+ exchange

The RTP substrates with Ti channel patterns were used for Cs^+ exchange. The orientation of the substrates was perpendicular to the ***c*** crystallographic direction, because this plane (***a-b***) is interesting since contains the non-critical phase matching type-II SHG directions for ytterbium laser emission wavelength range (from 985 to 1118 nm).

The Cs^+ diffusion was carried out in a crucible filled with 25 g of $CsNO_3$ at 425 ºC. The sample was immersed 6 mm below the surface of the melt in a horizontal way, stirred at 40 rpm and maintained in these conditions during 2 h.

III. CHARACTERIZATION

A. Near Field Pattern and Transmission Losses

A CCD camera was used to obtain the near field pattern of the channel waveguides. The modes were exited using objective microscopes and a He-Ne laser emitting at a wavelength of 632 nm and a Ti:Saphire emitting at a wavelength of 972 nm. As an example, figure 2 shows the near field pattern of the TM_{01}, TM_{11} and TM_{00} modes at a wavelength of 972 nm.

To estimate the scattered losses, a modified simple transmission method was used. Modified means that we took into account some corrections, such as Fresnel losses, the mismatch between the spot of the laser and the area of the channel and finally the losses due to the transmission of the microscope objectives. The upper limit of the transmission losses was 1.5 dB/cm.

B. Second Harmonic Generation experiments

In order to check the Second Harmonic Generation (SHG) inside the channel waveguides, a pulsed laser beam from an OPO was coupled into the channel waveguides. In this case, an achromatic half-plate was placed between the laser source and the sample at an angle of 22.5 º to ensure the type II SHG. The guided green light obtained exclusively inside the channel

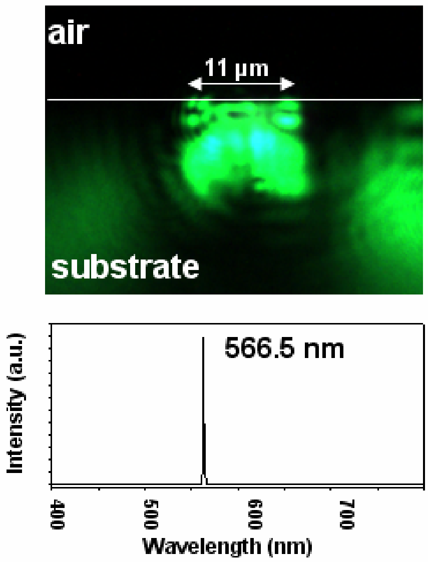

Figure 3. Type II SHG obtained in a 11 μm width Cs^+ ion exchanged channel waveguide.

was collected with a CCD camera, and it is shown in figure 3. This figure shows the type II SHG obtained using the 11 μm width channel. The pumping wavelength was 1133 nm, and the green light obtained had a wavelength of 566.5 nm.

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