2302

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Ti:sapphire rib channel waveguide fabricated by reactive ion etching of a planar waveguide

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We were successful in creating 1.4-µm high ribs in a Ti:sapphire planar waveguide by reactive ion etching. Optical investigations of the obtained structure showed channel-waveguide fluorescence emission of the Ti:sapphire layer after Ar-ion excitation.

Recently, Ti:sapphire planar waveguides were fabricated [1] by pulsed laser deposition on sapphire substrates. Due to their high crystallinity, optical quality, and low-loss propagation laser oscillation was successfully demonstrated [2]. Such planar waveguides can also be used as coherent broadband emitters for interferometric applications [3]. Fabrication of a channel waveguide by structuring of such a planar waveguide would allow us to obtain fluorescence emission with improved coherence and efficiency in the case of broadband emission and a reduced pump threshold and increased output power in the case of laser oscillation.

Here we report, to our knowledge, the first channel-waveguide emission from a Ti:sapphire structure. We engraved channels of 1.4-µm depth in a 10-µm thick Ti(0.1%):sapphire planar waveguide by reactive ion etching (RIE). RIE is a well-established method for patterning semiconductor materials, but until recently [4, 5] less attention was paid to the fabrication of microstructures in sapphire or Ti:sapphire.

Fabrication of structures with low surface roughness is essential for receiving low-loss propagation in channel waveguides. First, we investigated the suitability of RIE and the structural properties of the etched areas in c-cut sapphire substrates. We spin-coated a polyimide mask of 12-µm thickness onto the surface of the sapphire substrate. This mask was structured by laser ablation with an ArF* excimer laser at $\lambda = 193$ nm. In this way, we defined channels of 100-µm width, 12-µm depth, and distanced by 15-µm in the polyimide. RIE was then performed in a BCl_3:Cl_2 atmosphere at 3 mTorr pressure by use of an inductive plasma system. The etch rate of the sapphire was 45 nm/min and the etching selectivity between the sapphire and the mask was 1:3.5. The obtained structures were investigated by profilometry. Additional results obtained by atomic force microscopy (AFM) show that the roughness of the sapphire substrates is lowered from an rms value of 15.9 nm to an rms value of 3.7 nm for the etched regions.

The same experimental conditions were used for the RIE of the Ti:sapphire planar waveguide. Figure 1 shows the rib profile of one of the RIE-etched regions of the Ti:sapphire planar waveguide.

We investigated the Ti:sapphire rib structures by optically pumping the waveguide with an Ar-ion laser that operated cw on all lines. The pump light was focused into the rib by a 16x microscope objective. The fluorescence emission from the rear end of the waveguide was collected by the same type of objective, passed through 2 OG 550 filters to cut off the residual transmitted pump light and imaged onto a CCD camera linked to a beam-analyzing software. The experimentally observed output profile (Fig. 2) of the fluorescence emission from the rib region demonstrates that a high confinement in both the vertical and horizontal directions was achieved. This profile fits well with the simulated fundamental-mode intensity profile (Fig. 3) at 800 nm for a 15-μm wide by 1.5 μm high rib in a 10-μm thick Ti:sapphire planar waveguide.

Further optical investigations of our rib structures are under way. These results will be reported at the conference.

References

[1] A.A. Anderson, R.W. Eason, M. Jelinek, C. Grivas, D. Lane, K. Rogers, L.M.B. Hickey, C. Fotakis, Thin Solid Films **300**, 68 (1997).

[2] A.A. Anderson, R.W. Eason, L.M.B. Hickey, M. Jelinek, C. Grivas, D.S. Gill, N.A. Vainos, Opt. Lett. **22**, 1556 (1997).

[3] M. Pollnau, R.P. Salathé, T. Bhutta, D.P. Shepherd, R.W. Eason, Opt. Lett. **26**, 283 (2001).

[4] J. Lancok, M. Jelinek, J. Bulir, P. Machac, Laser Phys. **8**, 303 (1998).

[5] S.H. Park, H. Jeon, Y.J. Sung, G.Y. Yeom, Appl. Opt. **40**, 3698 (2001).