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Encoding of volume gratings in pulsed-laser-deposited Ti:sapphire waveguides by femtosecond UV laser irradiation and a phase mask

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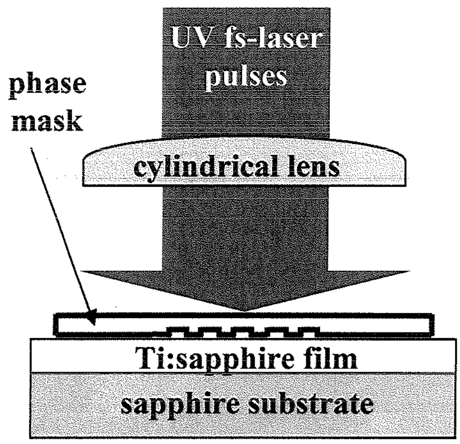
Ti:sapphire is a widely used laser material with broad tunability (650-1100 nm), which makes it suitable for the development of short pulse and broadly tunable lasers. Development of Ti:sapphire channel waveguide lasers has recently attracted attention and various techniques such as pulsed laser deposition (PLD) [1], and proton implantation [2] have been used for their realization. The cavity of these lasers was formed by attaching thin dielectric mirrors at the end-faces of the waveguides. However, this approach induces instabilities in the laser operation due to etalon effects between the mirrors and the substrate, and imposes limitations on the integrability of the device. A route to improve both performance and scale of integration would be to substitute the cavity optics by grating structures incorporated in the waveguides. Here, we report on the fabrication of Bragg gratings within crystalline Ti:sapphire layers grown on sapphire substrates by PLD. Encoding was performed by focusing the third harmonic output from a femtosecond Ti:sapphire laser (266 nm, 110 fs, 1 KHz 170 μJ pulse energy) with a 75 mm cylindrical lens through a silica phase mask optimized for use at 266 nm with a period of 1077 nm and a residual zero order intensity of less than 1%. Recording of gratings was monitored with a He-Ne laser at λ=633 nm by illuminating the sample from the top of its surface and measuring its diffraction efficiency. A diffraction efficiency value of 19% was obtained for a film with a thickness of 5 μm. This would equate to a diffraction efficiency of approximately 50 % for an equivalent 10-μm-thick film. The recorded gratings were stable for annealing temperatures up to ~70°C. Since generation of gratings was not observed in commercial bulk Ti:sapphire crystals, we speculate that formation in PLD-grown films may result from refractive index modulation due to structural rearrangements at defect sites such as F^+ color centers (oxygen vacancies occupied by one electron) that are present in the deposited layers. Such rearrangements would lead to the formation of metastable states in the film. The thermal stability of gratings depends on the barrier height that separates the metastable from the initial state. The focus of current work is on the further investigation of the recording mechanism as well as on the incorporation of Bragg thick gratings into Ti:sapphire channel waveguides and results will be reported.



Schematic of the experimental set-up for recording of gratings in PLD-grown Ti:sapphire films

[1] C. Grivas, L. Laversenne, C.N. Borca, P. Moretti, D.P. Shepherd, R.W. Eason, M. Pollnau Opt. Lett. **31,** 3450 (2006)

[2] C. Grivas, D.P. Shepherd, T.C. May-Smith, R.W. Eason, M. Pollnau Opt. Express **30,** 210, (2005)