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Submitted to CLEO/IQEC 2004 San Francisco, USA 16-21 May 2004

Ar^+ beam etched Ti:sapphire rib waveguides: a route for the development of broadband fluorescence and channel laser sources

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Abstract: Ar^+-beam-milled rib waveguides were fabricated in pulsed-laser-deposited Ti:sapphire films and overgrown by a 5 μm thick sapphire layer to reduce losses. They show broadband single transverse-mode fluorescence emission and potential for development of laser sources.

OCIS codes: (140.3380) Laser materials; (170.4500) Optical coherence tomography; (230.7380) Waveguides channelled; (310.2790) Guided waves

Active rib waveguides with depths and widths varying from 3 to 5 μm and 9 to 24 μm respectively, have been structured by Ar^+ beam etching of Ti:sapphire layers grown by pulsed laser deposition on sapphire substrates [1]. The specific waveguide geometry leads to strong optical confinement [Fig. 1] and measurement of the propagation factors, M_x^2 and M_y^2 indicate single transverse mode fluorescence emission. The fluorescence output power was of the order of 300 μW when the structures were pumped by a 3 W multiline argon laser. Loss measurements in the channel structures were performed via the self-pumped phase conjugation (SPPC) technique. Losses were essentially at the same levels as the unstructured planar waveguide host (~1.6-1.8 dB/cm) suggesting therefore that there is no significant additional contribution to loss from the rib fabrication procedure. This is thought to be an attribute of the very smooth morphological features of these structures as revealed by SEM studies [Fig. 2].

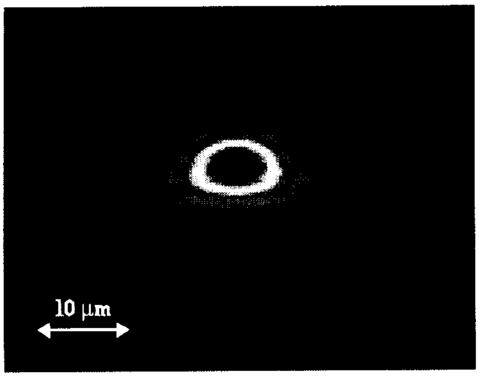

Fig. 1: Fluorescence emission profile from a Ti:sapphire rib waveguide with a depth of 5 μm and a width of 14 μm waveguide

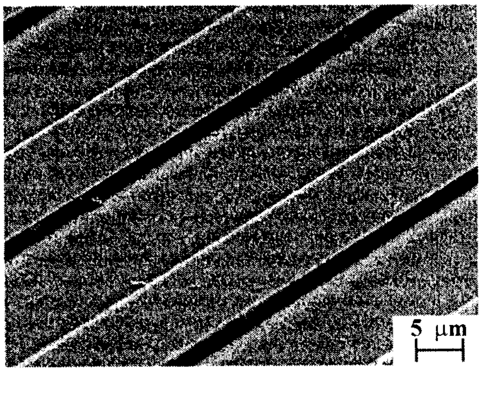

Fig. 2: Scanning Electron Microscope pictures of Ar^+ beam structured ribs in a 10 μm thick pulsed-laser-deposited planar waveguide

The focus of the work is now on the increase of the output power by exploiting the amplified spontaneous emission (ASE) as well as by developing efficient laser sources from the rib structures. To form the laser cavity apart from an in-coupling mirror with a transmission of 86% at the pump wavelength a set of mirrors with transmission values between 0.2% (HR mirror) and 26% at the laser wavelength, are successively used as output couplers. Although with the current level of propagation losses demonstration of laser action in a Ti:sapphire channel waveguide should be possible [2], we have attempted to decrease the loss levels by overgrowing a 5 μm thick sapphire capping layer on top of the rib structures using pulsed laser deposition (PLD). This configuration can lead to a reduction of the adverse effect of the particulates [3], which are a seemingly inherent part of the growth technique, on the waveguiding performance. As a consequence a significant drop of the laser threshold from the current levels of 0.56 W) is expected as well as an increase in the slope efficiencies (4% and 26% for output couplers with a transmission of 5% and 35% at the lasing wavelength respectively.

The modal characteristics as well as the high efficiency of this waveguide geometry would make such a laser source a very interesting candidate for optical coherence tomography applications.

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