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Single transverse-mode laser operation of Ti:sapphire rib waveguides

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Ti:sapphire is an attractive laser medium for the development of miniature lasers with widely tunable output (650-1100 nm). However, due to its low peak emission cross section and short fluorescence lifetime, high pump power densities are required to achieve efficient CW lasing. A route to address this problem is to adopt channel waveguide geometries, which are characterized by lower laser thresholds than their planar waveguide counterparts due to the additional lateral confinement and excellent overlap between the laser and pump modes provided that their fabrication process does not introduce any additional loss. Having already demonstrated laser action from pulsed-laser-deposited (PLD) Ti:sapphire planar waveguides [1], we report here on the single mode laser operation of Ti:sapphire rib waveguides. They were fabricated in PLD-grown films, using photolithography and ion beam etching [2] and were then coated by a 5 μm thick sapphire capping layer to reduce scattering losses.

The laser performance of the rib waveguides was investigated using an extended cavity configuration (Fig. 1), which has the potential to allow introduction of intracavity elements for modulation or tuning. Despite the use of intra-cavity optics, lasing occurred at an absorbed pump power threshold of 265 mW for ribs with height 3.5 μm and width 10 μm when the cavity was formed by two HR mirrors. This is a reduction by more than a factor of 2 in comparison to their monolithic, but not overclad, planar laser counterpart, for which the threshold was 560 mW [1]. The lasing spectrum was centred at 792.5 nm, and the intensity profile of the laser mode indicates strong optical confinement (Fig. 2). The laser output was π-polarized and measurements of the beam propagation factors (M^2), performed with a beam propagation analyzer, showed near-diffraction-limited output with values of 1.3 and 1.2 for the horizontal and vertical axes, respectively. Figure 3 shows the laser output characteristics as a function of the absorbed power using a T = 4.6% output coupler and a duty cycle of 8%. A quasi-CW output power of 27 mW was measured for an absorbed power of 1 W and a slope efficiency of 5.3% with respect to the absorbed pump power was obtained, which is higher than that of the planar laser version of this waveguide (4%) with the same output coupling [1]. This indicates that the propagation loss of the fabricated structure is certainly not greater than that of its monolithic, but not overclad, planar counterpart.

With a view to implementing these laser sources in Optical Coherence Tomography (OCT), current work concentrates on the mode-locked operation and production of ultra-short pulses from these structures as well as the development of amplified spontaneous emission (ASE) sources. These approaches offer the possibility to increase the spectral bandwidth of their laser and fluorescence emission, respectively, and in turn their high longitudinal resolution.

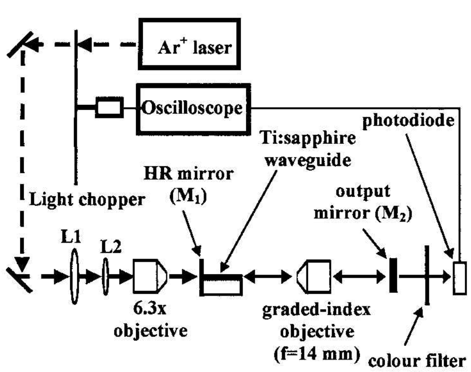

Fig. 1. Experimental set-up for the investigation of the rib waveguide lasers. The laser cavity is formed by the mirrors M_1 and M_2.

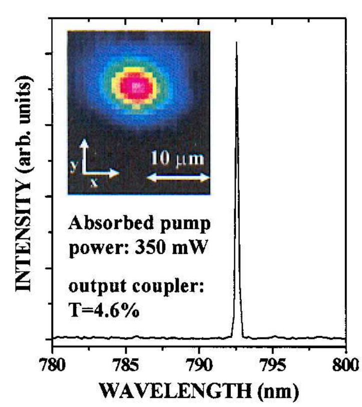

Fig. 2. Laser spectrum and mode intensity profile from a rib waveguide with 3.5 μm height and 10 μm width.

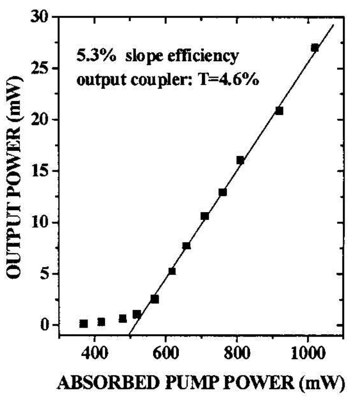

Fig. 3. Output power versus absorbed pump power for a rib waveguide laser with 3.5 μm height and 10 μm width.

[1] 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).

[2] C. Grivas, D.P. Shepherd, T.C. May-Smith, R.W. Eason, A. Crunteanu, M. Pollnau, M. Jelinek, IEEE J. Quantum Electron. **39**, 501, (2003).