Laser Performance of a PLD-Grown Yb:LuAG Double-Clad Planar Waveguide

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A growing demand for compact high-power laser sources has recently stimulated significant interest in the development of planar waveguide laser geometries compatible with high-power laser diode bars and producing high beam quality laser output [1,2]. This can be achieved by use of cladding-pumping techniques such that the pump and the laser signals are guided by different, but spatially overlapping, waveguides. By engineering the doped region to be the central layer of a double-clad planar waveguide, fundamental-mode selection can be achieved [1]. Fabrication of these structures is possible using pulsed laser deposition (PLD), which combines relatively high growth rates (up to 25-µm per hour [3]), the ability to dynamically control local refractive index [4], and the capability to grow active hetero-epitaxial multi-layered structures [5].

In this work we present a 4 µm-thick 7at.% Yb-doped LuAG core layer bounded by two 2-µm-thick undoped LuAG cladding layers, which was grown on a YAG substrate by use of PLD. X-ray diffraction analysis confirmed a film with predominantly <100> crystal orientation. Absorption and stimulated emission cross sections were calculated using the measured excited state lifetime and fluorescence spectrum, which compares well with previously reported spectroscopy of Yb:LuAG-crystals grown by traditional methods. An upper limit for the propagation losses of the waveguide were estimated to be 1.2 dB·cm^{-1} by measurement of the transmission of a 1064nm laser beam focussed into the end facet of the waveguide.

Laser experiments were carried out with a quasi-monolithic plane-plane cavity shown schematically in Fig.1(a). A conduction-cooled 40 W diode-laser bar emitting at 940 nm wavelength, with fast- and slow-axis collimation (FAC/SAC), was used as a pump source. Lasing was obtained for both simple Fresnel reflection and for output couplers with reflectance of 30% or 50% (M2), the measured performance is illustrated in Fig. 1(b).

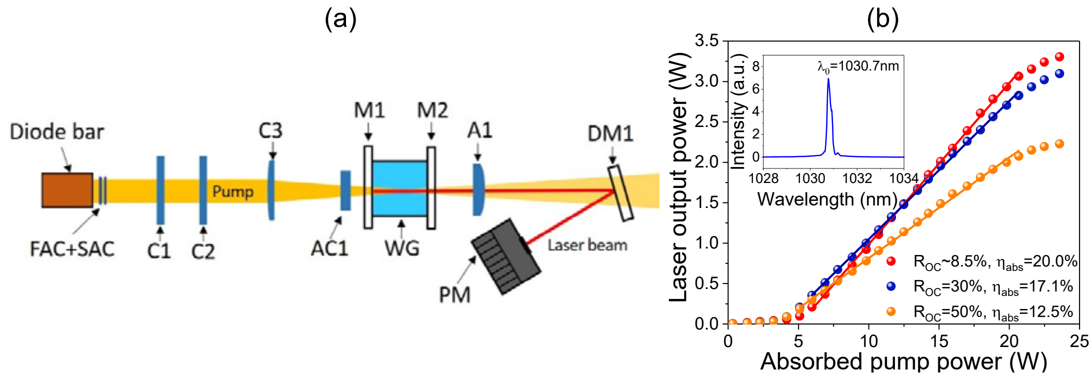

Fig. 1 Yb:LuAG double-clad waveguide laser (a) experimental setup and (b) input-output power characteristics

The best laser performance was achieved with a high-reflectance mirror (M1) and Fresnel reflection at the output facet giving a maximum output power of 3.3 W at 1030.7 nm with a 20 % slope efficiency. This is the first demonstration to our knowledge of a Yb:LuAG crystalline planar waveguide laser, which has a slope efficiency of more than twice that reported previously for a ceramic Yb:LuAG waveguide laser [6]. The measured laser spectrum is displayed in Fig.1(b) as an insert. Thermally induced roll-over of the lasing output was noticeable at pump power levels above 20 W, which is expected to be mitigated with better heat-sinking. Using a modified Caird analysis for the case of large output coupler transmission and losses, the single pass parasitic loss in the cavity was calculated to be ~1.8 dB. Improved laser performance and the beam quality is expected with further growth optimisation, which will be enabling for the construction of efficient high-power lasers and amplifiers.

References

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