First laser operation of an epitaxially grown $Tm:Y_2SiO_5$ waveguide

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With Ti:Sapphire pumping, using a 2% output coupler, a threshold of 62mW and a slope efficiency of 14% was achieved at 1885nm in a $Tm:Y_2SiO_5$ waveguide laser grown by Liquid Phase Epitaxy.

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Liquid Phase Epitaxy (LPE) is a promising technique for producing planar waveguide lasers. This method has already achieved good results with $Y_3Al_5O_{12}$ (YAG) [1,2]. In this paper we report the growth and laser operation of layers of a new material: Y_2SiO_5 (YSO) which is a promising laser host especially doped with Tm for 2µm laser operation [3].

In order to realise epitaxial layers, we have prepared YSO substrates with (010) orientation from Czochralski crystals grown at LETI. The Liquid Phase Epitaxy procedure used here is the same as that for the growth of YAG epilayers [4]. The epitaxial melt was a mixture of the solute: Y_2O_3 (+ Tm_2O_3) + SiO_2 (in excess) and the solvent: PbO + B_2O_3. Growth temperatures were in the 950 to 1000°C range. Substitutions of Yttrium by Thulium (1.7 to 4.5 at%) have been performed. As the lattice mismatch is increasing, as reported previously [5], a codoping with Germanium was tested. With 1.4 to 2.4 at% Germanium, a small lattice mismatch was successfully achieved. The quality of the YSO layers can be very good for well controlled growth conditions, but are dependant on the substrate quality.

The room temperature fluorescence spectra for the 3F4 → 3H6 emission of Tm:YSO epilayers exhibit a broad band in the 1600-2000 nm region. Fluorescence decays of the 3F4 level of Tm^{3+} in various concentrated epilayers have been investigated at room temperature. We obtained 1.6ms for a 1.7% Tm doped epilayer, 1.1ms for a 4.5% Tm doped epilayer, and 1.5ms for a 2.6% Tm, 1.4% Ge codoped epilayer. In bulk crystals, comparable values of 1.56ms for 1% Tm and 0.98ms for 5% have been reported [3], indicating that the codoping with Ge doesn't change the crystallographic site of Tm^{3+}.

The 1885 nm laser performances of a waveguide with a 2.6% Tm doping level, a 9.8µm active epilayer thickness, and various lengths (4 and 5mm) have been investigated using two plane mirrors butted directly to the end faces of the waveguide to form the resonator cavity. Ti:Sapphire pumping has been used at 792nm.

With a high reflectivity output coupler, an absorbed power threshold of 58mW was obtained. With a 2% transmission output coupler, the threshold rose to 62mW and a slope efficiency of 14% was achieved. These laser performances are comparable to the best results published (YSO:Tm 5% doped, threshold ~176mW, slope efficiency ~17%)[3], and in fact are better in terms of threshold.

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