Lattice matching and microstructuring of Gd^{3+}, Lu^{3+} co-doped $KY(WO_4)_2$:Tm^{3+} Channel Waveguide Lasers

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Abstract: Lattice-matched $KY(WO_4)_2$:Gd^{3+},Lu^{3+},Tm^{3+} layers with a thickness of 6 µm have been grown onto pure $KY(WO_4)_2$ substrates. Channel waveguides of 7.5 µm to 12.5 µm width have been microstructured to a depth of 1.5 µm using Ar^+ beam milling. Laser experiments with butt-coupled mirrors demonstrate laser oscillation near 1844 nm while pumping at 792 nm.

Planar waveguide lasers in KYW:Tm have been demonstrated in an open cavity configuration [1]. In this paper we report on the fabrication and preliminary performance of channel waveguide lasers in KYW:Tm.

KYW thin layers co-doped with Gd^{3+}, Lu^{3+}, and a Tm^{3+} concentration of 1.5 at.% were grown by liquid-phase epitaxy from a $K_2W_2O_7$ solvent onto undoped KYW substrates. The compressive and tensile strains are balanced out by combining a doping concentration of 19.6 at.% Gd^{3+} and 18.9 at.% Lu^{3+}, minimizing the lattice stress [2]. Besides, a refractive index contrast of 6×10^{-3} between the grown layer and the substrate was obtained by replacing Y^{3+} with optically inert Gd^{3+} and Lu^{3+} ions, both of which exhibit higher refractive indices [3,4]. The obtained refractive index contrast ensures strong confinement along the b-crystallographic axis of the pump and laser modes at 802 nm and 1844 nm, respectively, while fabrication of ridge-type waveguides is facilitated by the shallow etch-depth requirements due to the small layer thickness. Single-mode laser operation in ridge-type waveguides is expected for a layer thickness of 6 µm, channel widths of 7.5–12.5 µm, and 4.5 µm remaining slab thickness.

A grown co-doped layer was lapped and polished down to the required thickness of 6 µm, after which a layer of photoresist (Fujifilm OiR 908/35) was deposited and patterned. Ar^+ beam milling of the rotating sample with an energy of 350 eV was used to imprint the channel pattern along the N_g optical axis into the optically active layer at a rate of 3 nm/min [5]. A scanning electron microscope (SEM) image of the resulting waveguides is shown in Fig. 1a. The patterned layer is overgrown with a pure KYW layer to reduce the optical loss and ensure good overlap between pump and laser modes.

Laser experiments with butt-coupled mirrors have been conducted on the KYW:Tm channel waveguide samples, showing laser operation at 1844 nm while pumping at 792 nm in N_p polarization, see Figs. 1b and 1c.

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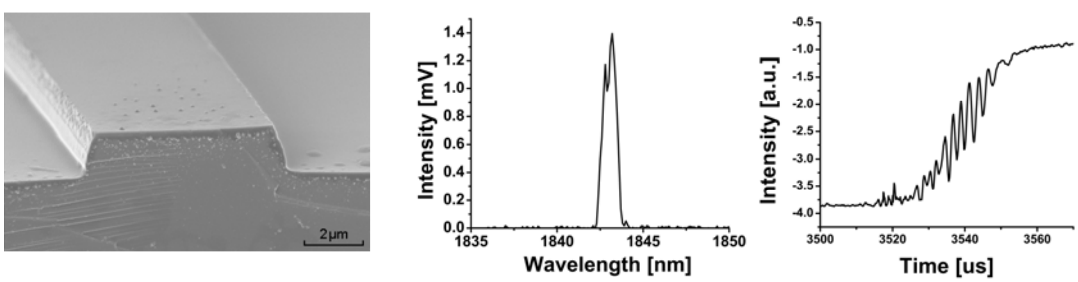

Fig. 1. (a) SEM micrograph of a ridge-type channel waveguide microstructured by Ar^+ milling, (b) emission spectrum and (c) relaxation oscillations of a KYW:Tm channel waveguide laser

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