

## Thin layers of $\text{KY}(\text{WO}_4)_2:\text{Yb}^{3+}$ for waveguide lasers

**Y.E. Romanyuk, C.N. Borca, and M. Pollnau**

*Advanced Photonics Laboratory, École Polytechnique Fédérale de Lausanne,  
CH-1015 Lausanne, Switzerland*

**L.L. Kuandykov**

*Ioffe Physico-Technical Institute, Politekhnicheskaya 26, 194021 Saint-Petersburg, Russia*

Monoclinic  $\text{KY}(\text{WO}_4)_2$  crystals doped with  $\text{Yb}^{3+}$  (KYW:Yb) are well known as gain media for high-power and femtosecond solid-state lasers. In particular, the  $\text{Yb}^{3+}$  ion in KYW exhibits an absorption maximum near 981 nm with a cross-section approximately 15 times larger than that of YAG:Yb. Beside bulk KYW:Yb crystals, intensive research is being conducted towards KYW:Yb thin layers. The advantages of the thin-layer geometry can be fully exploited in a waveguiding structure, in which high pump-power densities and excellent overlap of pump and resonator modes are obtained. This approach requires the fabrication of high-quality KYW:Yb layers on appropriate substrates with close-to-perfect interfaces to ensure low-loss propagation.

Liquid-phase epitaxy (LPE) of rare-earth-ion doped KYW layers from a low-temperature chloride solvent has been reported recently [1]. However, 3D island nucleation generated many insertion defects and limited the maximum layer thickness to approx. 10  $\mu\text{m}$ . Using  $\text{K}_2\text{W}_2\text{O}_7$  as a solvent yielded better layer quality and KYW:Yb layers could be pumped perpendicular to the layer in order to achieve continuous-wave (CW) laser operation [2]. In the present study we also used LPE from the  $\text{K}_2\text{W}_2\text{O}_7$  solvent. Undoped KYW crystals grown by a modified Czochralski method with laser-grade polished (010) faces served as substrates. We employed the vertical dipping technique and the substrates were immersed only partially in the molten solution in order to facilitate precise polishing of the layer surface parallel to the interface. Substrate position and rotation rate were optimized by numerical simulation of the liquid flow in the crucible to obtain uniform layer thickness. A relative supersaturation of 1.2 mg/(K\*g) solution at the growth temperature of 1170 K resulted in layers with thickness up to 100  $\mu\text{m}$  and  $\text{Yb}^{3+}$  concentrations ranging from 1 to 3 at% with respect to  $\text{Y}^{3+}$ . Dipping the substrate at 0.1-0.3 K above the saturation point eliminated the surface defects and assured a defect-free interface. Afterwards, the layer surface was polished to remove flux residuals and growth steps. Several active layers were overgrown by 20- $\mu\text{m}$  thick undoped KYW overlays in order to obtain buried active structures with symmetric refractive-index profile in the waveguide structure.

CW lasing in both surface and buried KYW:Yb planar layers was demonstrated at 1025 nm in the fundamental mode [3]. The maximum output power was 290 mW and the slope efficiency was as high as 80.4%, which the highest ever reported value for a KYW:Yb laser.

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[2] A. Aznar, R. Solé, M. Aguiló, F. Diaz, U. Griebner, R. Grunwald, V. Petrov, *Appl. Phys. Lett.* 85 (2004) 4313.

[3] Y.E. Romanyuk, C.N. Borca, M. Pollnau, S. Rivier, V. Petrov, U. Griebner, "Surface and buried planar waveguide lasers based on  $\text{KY}(\text{WO}_4)_2:\text{Yb}^{3+}$ ", submitted to Conference on Lasers and Electro-Optics Europe, Munich, Germany, 2005.