

Rare-earth-ion doped KY(WO₄)₂ optical waveguides grown by liquid-phase epitaxy

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Rare-earth-ion doped KY(WO₄)₂ (hereafter KYW) is a promising material for novel solid-state lasers. Low laser thresholds, high efficiencies, high output powers, and third-order nonlinear effects have stimulated research towards miniaturized thin-film waveguide lasers and amplifiers for future photonic devices. Active films can be fabricated by liquid-phase epitaxy (LPE), pulsed laser deposition, ion implantation, and diffusion bonding [1].

We report here on the low-temperature liquid-phase epitaxy of KYW:RE³⁺ single crystalline layers (RE = Tb, Dy, Yb). Undoped KYW crystals grown by a modified Czochralski method with laser-grade polished (010) faces were used as substrates. The ternary chloride eutectic NaCl-KCl-CsCl with a melting temperature of 482°C was employed as a solvent. The layers were grown at start temperatures as low as 540°C, which is favorable in order to decrease the thermal stress due to differences in the thermal expansion coefficients of substrate and layer [2]. However, at high RE-dopant concentrations elastic stress due to the lattice parameter misfit between substrate and layer is often released by the formation of a crack network along certain cleavage planes. X-ray diffraction measurements confirmed that the epilayers with thicknesses of 5-10 μm and areas of up to 0.5 cm² were strictly oriented in [010] direction. The doping level was 1-10 at% of RE ions with respect to the Y³⁺ site and the incorporation decreased in the series Tb³⁺>Dy³⁺>Yb³⁺ because of the increasing misfit between the ion radii of the RE and the replaced Y³⁺ ion.

Crack-free layers were tested as planar waveguides. Both end-faces of the samples were polished and laser light was coupled into the waveguides by focusing with a microscope objective. The outcoupled light was imaged onto the sensor of a CCD-camera using a 10x microscope objective. Planar waveguiding of 633-nm light from a helium-neon laser was observed. Argon-ion laser light at 488 nm was coupled into the waveguide to excite the Tb³⁺ ions, which exhibited fluorescence waveguiding in the yellow and red spectral region. A filter was used to block the residual pump radiation transmitted through the waveguide. In Fig. 1, the waveguide mode of the outcoupled fluorescence from a 2.5-μm thick, 10% Tb³⁺-doped KYW layer is shown.

These waveguides are promising for the implementation of active waveguide devices doped with different rare-earth ions, which can be incorporated into the planar KYW films. In the future, we will investigate surface structuring of these films with the final target to create channel waveguide lasers and amplifiers.

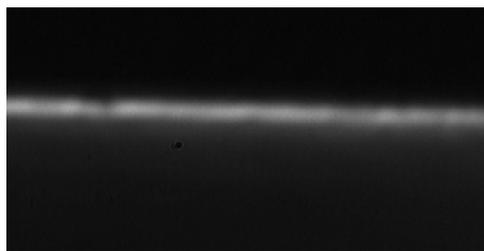


Fig. 1. Image of the guided fluorescence of the Tb³⁺ ions in the KYW film.

[1] M. Jelinek, Czech. J. Phys. **53**, 365-448 (2003).

[2] M.C. Pujol, X. Mateos, R. Solé, J. Massons, J. Gavalda, F. Diaz, M. Aguilo, Mat. Sci. Forum **378**, 710-715 (2001).