

Rare-earth-ion doped KY(WO₄)₂ thin layer growth by low-temperature 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 [1]. 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, see, e.g., [2,3].

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 solvent. This flux dissolves all the solute components, possesses low viscosity and volatility, is non-toxic and available in high purities. 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 [4]. Only at high RE-dopant concentrations, elastic stress due to the lattice parameter misfit between substrate and layer is often released by formation of a crack network along certain cleavage planes.

Typically, the growth started with the nucleation of 3D islands, which then coalesced into a uniform epitaxial layer with areas of up to 0.5 cm² (Volmer-Weber growth mode). The average growth rate was 2-6 unit cells per minute. X-ray diffraction measurements confirmed that the epilayers were strictly oriented in [010] direction. Elemental composition, nano-hardness, and elastic constants of the layers were determined. RE-ion incorporation into the KYW host decreases in the series Dy³⁺ ≈ Tb³⁺ > Yb³⁺ according to the increasing misfit between the ion radii of RE and replaced Y³⁺ ion. The influence of solute concentration, growth temperature, and doping level was investigated in order to produce layers up to 20-μm thick and with low defect concentration, which can be suitable as optically activated waveguides.

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[3] M. Jelinek, Czech. J. Phys. **53** (5), 365-448 (2003).

[4] M.C. Pujol et al., Mat. Sci. Forum **378** (3), 710-715 (2001).