Liquid-phase epitaxy and optical investigation of $KYb(WO_4)_2$ thin layers

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In recent years, Yb^{3+} has attracted much attention as an activating ion because of its small quantum defect for laser emission from $^2F_{5/2}$ to $^2F_{7/2}$ at ~1.03 µm [1], which provides high efficiency and reduced heat generation. Of high practical interest is the thin-disk laser concept [2], which possesses a tremendous advantage over rod lasers because of its axial-cooling approach and consequent weak thermal lensing and good beam quality.

A promising material for Yb^{3+} thin-disk lasers is $KYb(WO_4)_2$ (KYbW) [3]. It can be grown from high-temperature solutions [4]. Nevertheless, the growth of high-quality, single-crystalline layers with thickness in the range of the absorption length of ~13 µm at 981 nm has as yet not been reported. A suitable substrate material is $KY(WO_4)_2$ (KYW), but the relatively large differences in the thermal expansion coefficients between KYW and KYbW along the [100], [001], and especially [010] directions [5] favor low temperatures for the hetero-epitaxial growth.

For the first time, we demonstrate liquid phase epitaxy (LPE) of KYbW layers. The layers were grown at start temperatures as low as 520°C, which is favorable in order to decrease the thermal stresses due to the differences in the thermal expansion coefficients of substrate and layer. Moreover, the choice of [010]-oriented substrates bypasses the large difference in the thermal expansion coefficient along the [010] direction. $KY_{1-x}Yb_x(WO_4)_2$ layers with varying x = 0.03-1.00 were grown by LPE. The chloride solvent consisted of the eutectic composition [6] 24.4 mol.% KCl, 30.4 mol.% NaCl, and 42.2 mol.% CsCl. The growth temperature spanned the range from 580 to 500°C and the cooling rate was 0.67-1.00 Kh^{-1}. Crack-free, transparent KYbW layers were grown on (010) substrates.

Spectroscopic investigations have shown that the lifetime of ~250 µs measured in our LPE-grown KYbW layers is dominated by radiative decay and is very similar to that measured in top-seeded-solution-grown bulk samples [4]. Fast energy migration among the Yb^{3+} ions and energy transfer to small amounts of Tm^{3+} and Er^{3+} ions present in the $YbCl_3$ reagent lead to visible upconversion luminescence in the layers under 981-nm excitation.

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