Liquid-phase epitaxy and optical investigation of stoichiometric $KYb(WO_4)_2$ 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 using the solvent $K_2W_2O_7$, at temperatures of 825-975°C, see e.g. Ref. [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 chloridic 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. A comparison of KYbW growth on (010) and (100) KYW substrates will be given, focusing on cracking problems. The surface morphology of the epitaxial layers will be discussed.

Spectroscopic investigations have shown that the lifetime of 250 μs measured in our LPE-grown KYbW layers 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. The results of laser experiments will be reported at the conference.

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