ROOM-TEMPERATURE 2-\(\mu\text{m}\) Ho: YAG AND 3-\(\mu\text{m}\) Er: YAG LASERS

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ROOM-TEMPERATURE 2-μm Ho:YAG AND 3-μm Er:YAG LASERS

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We demonstrate fundamental laser properties of Cr-sensitized Tm,Ho,Er-garnets like YAG, YSAG and YSGG. In Cr,Tm,Ho: doped YAG, YSAG and YSGG crystals cw-lasing is achieved with efficiencies up to 41%. Laser operation was also obtained under flashlamp pumping. Even Cr,Er: and Cr,Er,Ho: doped YAG and YSGG crystals oscillate in a cw-mode. All these lasers are working efficiently at room-temperature.

Cr$^{3+}$ is known as an efficient sensitizer for rare earth ions as Nd$^{3+}$, Tm$^{3+}$, Ho$^{3+}$ and Er$^{3+}$ in garnets with a low crystal field for the octahedral site like GSGG, GSAG, YSGG, YSAG. But even in YAG with a rather narrow emission band of Cr$^{3+}$ at a strong crystal field site, Cr$^{3+}$ acts as an efficient sensitizer for Tm$^{3+}$, Ho$^{3+}$ and Er$^{3+}$ because of the sufficient overlap between the Cr$^{3+}$ emission and the Tm$^{3+}$, Ho$^{3+}$ and Er$^{3+}$ absorption in YAG /1,2/. The Ho$^{3+}$ and Er$^{3+}$ lasers are working under cw-, quasi-cw-laser- and flashlamp-excitation at room-temperature.

![Fluorescence of Cr,Tm,Ho:YAG](image-url)
Fig. 2: Input versus output for Cr,Tm,Ho:YAG under quasi-cw-excitation at room temperature.

Fig. 3: Fluorescence of Cr,Er:YAG

The Ho$^{3+}$-laser is emitting in the wavelength region between 1.9 and 2.1 μm. Fig.1 shows the fluorescence of Cr,Tm,Ho:YAG. The achieved power slope efficiencies of 33% in YAG and 41% in YSGG demonstrate the very efficient conversion of the visible excitation quanta down to the infrared region within the Tm$^{3+}$ ions with a quantum efficiency of nearly 2. Fig.2 shows input/output curves of Cr,Tm,Ho:YAG.
lasers. Under flashlamp pumping power slope efficiencies of more than 1% and pumping thresholds of less than 255 are obtained.

The Er\(^{3+}\)-laser at wavelength between 2.6 and 2.9 μm is realized with YAG as well as with YSGG crystals. Fig.3 shows the fluorescence of Cr,Er:YAG. The main problem for this Er\(^{3+}\)-laser is the longer lifetime of the lower laser level (\(4I_{11/2}\)) compared to the lifetime of the (\(4I_{13/2}\)) upper laser level. The difference is up to one order of magnitude. One possibility to decrease the lower level lifetime is quenching that level by codoping with Ho\(^{3+}\). Fig.4 shows input output curves for Cr,Er:YSGG and for Cr,Er,Ho:YSGG.

The efficiency of the Tm (\(3F_4 - 3H_4\)) - (\(3H_6 - 3H_4\)) energy down conversion is demonstrated by power slope efficiencies of the 2 μm Ho-laser of more than 40% under pumping in the visible wavelength region. For the Er\(^{3+}\) (\(4I_{11/2} - 4I_{13/2}\)) laser cw-lasing at room-temperature is achieved for the first time. Likewise it is shown that Cr\(^{3+}\) is an efficient sensitizer for rare earth ions even in YAG.

References:
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