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To cite this version:


HAL Id: jpa-00227087
https://hal.archives-ouvertes.fr/jpa-00227087
Submitted on 1 Jan 1987

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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.

Cr³⁺ is known as an efficient sensitizer for rare earth ions as Nd³⁺, Tm³⁺, Ho³⁺ and Er³⁺ 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 Cr³⁺ at a strong crystal field site, Cr³⁺ acts as an efficient sensitizer for Tm³⁺, Ho³⁺ and Er³⁺ because of the sufficient overlap between the Cr³⁺ emission and the Tm³⁺, Ho³⁺ and Er³⁺ absorption in YAG/1,2/. The Ho³⁺ and Er³⁺ lasers are working under cw-, quasi-cw-laser- and flashlamp-excitation at room-temperature.

Fig.1: Fluorescence of Cr,Tm,Ho:YAG
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 $\text{Er}^{3+}$-laser at wavelength between 2.6 and 2.9 $\mu$m is realized with YAG as well as with YSGG crystals. Fig.3 shows the fluorescence of Cr,Er:YAG. The main problem for this $\text{Er}^{3+}$-laser is the longer lifetime of the lower laser level ($^{4}I_{11/2}$) compared to the lifetime of the ($^{4}I_{13/2}$) 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 $\text{Ho}^{3+}$. Fig.4 shows input output curves for Cr,Er:YSGG and for Cr,Er, Ho:YSGG.

The efficiency of the Tm ($^{3}F_{4}$ - $^{3}H_{6}$) - ($^{3}H_{4}$ - $^{3}H_{4}$) energy down conversion is demonstrated by power slope efficiencies of the 2 $\mu$m Ho-laser of more than 40% under pumping in the visible wavelength region. For the $\text{Er}^{3+}$ ($^{4}I_{11/2}$ - $^{4}I_{13/2}$) 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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