Yb^{3+}-doped optimized laser crystals : Crystal growths, optical spectroscopy and combinatorial approach to study concentration quenching mechanisms.

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1.Presentation of our approach.

Our scientific program is involving different crystal growths, optical spectroscopy analysis, criteria of evaluation and a new combinatorial approach to study concentration quenching mechanisms in Yb^{3+} -doped oxide or fluoride laser crystals which are diode-pumped [1]. Among crystalline families which provide the best expected performances, we have choose to grow crystalline fibres as sesquioxides, oxyapatites, niobates and garnets pulled either from the Laser Heated Pedestal Growth (LHPG) or the Micro-Pulling Down (µ-PD) technique. Bulky samples have also been grown either by the top nucleated floating crystal (TNFC)as tungstates or by the Czochralski (CZ) technique as garnets, and molybdates.

Optical spectroscopy of all Yb^{3+}-doped crystals have been analyzed by researching electronic transitions among vibronic transitions. In addition, a new combinatorial chemistry approach has been pointed out to study the Yb^{3+} radiative lifetimes and concentration quenching processes in these laser crystals.

2.Samples of Yb^{3+}-doped laser crystals which have been grown and analyzed:

-Y_2O_3 yttria, Sc_2O_3 scandia, Lu_2O_3 lutecia sesquioxides, LiNbO3 (LNB) lithium niobate, and $Y_3Al_5O_{12}$ yttrium aluminium garnet (YAG), grown by the the Laser Heated Pedestal Growth (LHPG) method,

-oxiapatite $Ca_8La_2(PO_4)_6O_2$ (CLYPA), $Y_3Al_5O_{12}$ yttrium aluminium garnet (YAG) and Ba2Na Nb5O15 (BNN) niobate grown by the Micro-Pulling Down Method,

-$KY(WO_4)_2$ potassium yttrium (KYW) tungstate and $KGd(WO_4)_2$ (KGW) potassium gadolinium tungstate grown by the the top nucleated floating crystal (TNFC).

-Gd_3Ga_5O12 (GGG) grown by the Czochralski technique.

3. Evaluation of Yb^{3+}-doped oxide crystals

Taking into account of the great number of Yb^{3+}-doped crstals, a need of a new evaluation of Yb^{3+}-doped crystals was necessary in order to predict the laser efficiency in a more realistic manner in different kinds of regimes. According to a new evaluation based on a quasi-three level laser model, [2], several Yb^{3+}-doped laser crystals have been evaluated for either oscillators or amplifiers.

The results of calculations is visualized in a two-dimensional diagram considering the laser extracted power and the slope efficiency. $KY(WO_4)_2$ (KYW) and $KGd(WO_4)_2$ (KGW),Y_2O_3 yttria, Sc_2O_3 scandia, Lu_2O_3 lutecia sesquioxides and YAB [$YAl_3(BO_3)_3$] have the highest laser potentialities in the CW regime, whereas C-FAP ($Ca_5(PO_4)_3F$) and S-FAP ($Sr_5(PO_4)_3F$) of apatite structure, oxiapatite $Ca_8La_2(PO_4)_6O_2$ (CLYPA), $Y_3Al_5O_{12}$ yttrium aluminium garnet (YAG), and tungstates are the most efficient when considering the small-signal gain in amplifier regime.

3. Combinatorial approach based on gradient concentration fibres

A new and original method has been pointed out to grow activator ion concentration gradient crystal fibres by using the LHPG (Laser Heated Pedestal Growth) technique [3]. In this technique a floating zone is created at the top of a vertical feed rod by a focused laser beam. Because of the lack of crucible and of the use of 200 watt power CO_2 laser, the LHPG technique is well adapted to high refractory crystals such as Yttria, Scandia, Lutecia sesquioxides and also garnets. This new approach is an efficient tool for measuring optical, spectroscopic or thermal properties in any type of

inorganic optical materials in which either activator ion or nominal composition concentrations can be changed. First of all, we have used the technique to study concentration dependences of the spectroscopic properties both in rare earth-doped and co-doped refractory sesquioxide crystals [4] and recently in Yb^{3+}-doped YAG. Radiative (self-trapping) and non-radiative energy transfers have been observed from the Yb^{3+} $^2F_{7/2} \leftrightarrow {}^2F_{5/2}$ IR transitions. The radiative lifetimes and the competition between radiative, non-radiative processes to unexpected ions and pair effects shown by green anti-Stokes emission will be described.

References

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