A New Combinatorial Chemistry Approach in Luminescent Materials Science: Application to Rare Earth (RE)–Doped Laser Crystals, (RE= Yb^{3+}, Er^{3+}, Ho^{3+})

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A new and original method allows us to grow rare earth concentration gradient crystal fibres by using the LHPG (Laser Heated Pedestal Growth) technique [1-3]. In this technique a floating zone is created at the top of a vertical feed rod by a focused laser beam. The floating zone motion is generated by the vertical displacement of the feed. During the translation, the feed progressively melts and behind the floating zone a crystallized rod is formed. The floating zone remains in equilibrium between the feed and the crystallized rod due to the superficial tensions [2]. 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 materials such as sesquioxides as yttria, scandia and lutecia and garnets as YAG. In the combinatorial approach that we are proposing, the LHPG technique is applied to a feed rod constituted by two ceramics parts A and B with different compositions [4]. When the molten zone moves along the feed rod, there is a mutual solubilization of A and B. As the solubilized amounts of A and B vary, the molten zone composition continuously changes inducing a progressive and continuous composition gradient along the crystallized rod.

First of all, we have used the technique to study spectroscopic properties concentration dependences of rare earth-doped and co-doped refractory sesquioxide crystals. Such samples are very promising laser crystals:bulky crystals have recently been made by the Bridgmann technique using rhenium crucibles [5] and mono-doped fibres have already been grown by the LHPG technique [6]. Then, we have applied the same approach to the famous YAG host, by growing Yb^{3+}-doped YAG laser crystal useful for diode pumped laser sources.

We shall describe the technique to grow samples with special gradient crystal fibres and we shall also show how to measure absolute concentrations of rare earth ions along the fibres. Then, we shall mainly analyse concentration dependences of dynamical processes of three rare earth resonant transitions, under selective laser pumping:

-Yb^{3+} with the $^2F_{7/2} \leftrightarrow {}^2F_{5/2}$ transition at around 980 nm, both, in Y_2O_3 and YAG

-Er^{3+} with the $^4I_{15/2} \leftrightarrow {}^4I_{13/2}$ transition at around 1540 nm, in Y_2O_3 and also in Yb^{3+}- Er^{3+}- co-doped Y_2O_3.

-Ho^{3+} with the $^5I_7 \leftrightarrow {}^5I_8$ transition at around 2050 nm in Y_2O_3.

Our main objective is to point out the interest to grow concentration gradient fibres as an original and efficient tool for spectroscopy of inorganic luminescent materials.

References

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