CRYSTAL GROWTH OF FLUORIDE SINGLE CRYSTALS FIBERS

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There is an increasing interest in single-crystalline fibers due to their unique properties for the production of a variety of optical and electronic devices. Single crystal fibers show a well-adapted as-grown shape to be readily used in many kinds of optical devices and their use as lasing element is very interesting to the development of compact laser systems. The study of the growth process of fluoride single crystal fibers was started in 2002. A commercial micro-pulling-down system was modified to the growth of fluoride fibers crystals and a second system projected in our laboratories is under construction. The growth process for high-quality LiF (FIG.1), $LiYF_4$ and Er^{3+} and Nd^{3+}-doped $LiYF_4$ (FIG.2) single crystal fibers were developed. The influence of the growth atmosphere and starting melt composition on growth process were studied. Transparent and single-phase fibers, regular in diameter (800 μm) and quite long (up to 100 mm), were obtained. The study of other fluoride laser active materials are under development.

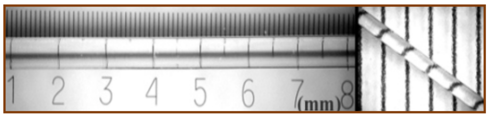

FIGURE 1 - LiF single crystal fibers.

FIGURE 2 - YLF:Nd single crystal fiber.

Phase diagrams of mixed systems

The study of a new class of rare earth mixed crystals, $LiGd_{1-x}Lu_xF_4$, is under way with the construction of the phase diagram of the system $LiF-GdF_3-LuF_3$. To determine the lutetium concentration that makes the system congruent, a partial phase diagram was constructed, where the mixture compositions were fixed at 50 mol% LiF: 50 mol% $Gd_{1-x}Lu_xF_3$ and the rare earth concentrations were changed from 0.5 up to 1. The congruent composition was determined to be 50 mol% LiF:50 mol% $Gd_{0.5}Lu_{0.5}F_3$ at 800°C. Initial results were obtained for the system $LiF-Gd_{0.5}Lu._{0.5}F_3$, using differential thermal analysis to construct the phase diagram. The characterization of the phases and the microstructure present in each two-phase region of the phase diagram was performed using scanning electron microscopy and powder X-ray diffraction. By the inspection of the microstructure, it was observed that samples with compositions rich in LiF presented the expected phases, which are LiF and $LiGd_{0.5}Lu_{0.5}F_4$. Conversely, near the stoichiometric composition, where the excess of LiF is smaller, the microstructure is composed by the trifluoride $Gd_{1-x}Lu_xF_3$ with x<30 mol%, the tetrafluoride $LiGd_{1-x}Lu_xF_4$ with x>60 mol% and a eutectic phase.

Crystal growth of fluoride single crystals.

XAS technique was utilized to characterize $LiY_{1-x}Lu_xF_4$:Nd crystals (x=0.9; 0.31; 0.47.3 and 1), concerning the local structure around the dopant, the site occupied by the dopant in the mixed systems and the distance and nature of the co-ordinating atoms. Computer modelling supported the data analysis and a precise model for such systems was derived.

$LiYF_4$:Ln (Ln= Er, Er and Eu, Er and Tb, Er and Yb, Dy and Tm, Tm and Ho, Pr) crystals were successfully grown by the Czochralski method, for spectroscopic studies of the ion energy transfer mechanisms and laser developments. Based on these studies a new Er diode pumped laser is under investigation using a $LiYF_4$:Er crystal (FIG.3) grown in our laboratories.

FIGURE 3 - $LiY_{0.85}Er_{0.15}F_4$ crystal

The synthesis, purification and growth of pure and Nd^{3+}-doped BaY_2F_8 was also studied. Small samples were prepared by the zone melting method. Crystals with 7x7 mm^2 in size were oriented by the Laue method (back-reflection mode) for optical measurements in the UV region. Fluoride materials doped with Nd^{3+} are very promising laser media emitting in the UV region. The optical properties of BaY_2F_8:Nd were compared with $LiYF_4$:Nd.