Photonic crystals

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This activity is devoted to the development optical crystals and fiber crystals based on fluoride and oxide compounds and their investigation as optical materials. The laboratory is divided into various facilities that cover all the aspects of the investigation of new materials from crystal growth to spectroscopy and first optoelectronic applications.

Growth lab

The facility consists of two Czochralski furnaces for growing bulk crystals and two micro-pulling down furnaces for fiber crystals.

Both the Czochralski furnaces operate in controlled Ar atmosphere at temperatures up to 1100C. All the growth process, including the diameter of the growing crystal, is computer-controlled and the samples obtained are of excellent optical quality. The crystals we have grown up to now are: $LiYF_4$, BaY_2F_8, KYF_4, $LiCaAlF_6$ doped with different rare earths or transition metal ions (Ce, Pr, Nd, Dy, Ho, Tm, Yb, Cr). The samples can be oriented, cut and polished to optical tolerances. Some of these samples have been used as active media in solid state lasers operating in the visible and near-infrared wavelength region at room temperature with high efficiences [1-4,7-9,15,17]. In particular laser action in the visible reagion has been obtained with a new type of pumping scheme [6], very wide tunability has been obtained in the 2 mm wavelength region in continuous wave regime[13] and high power Q-switched results have been presented in the 1 mm wavelength region [18].

The micro-pulling down method is the natural evolution from macroscopic systems (bulk crystals) to micro-systems (fibers), and it is aimed to an innovative approach to the development of laser sources and to the study of frequency conversion devices. The development of single crystalline fibers offers at least two advantages with respect to bulk crystals, namely the possibility of studying new type of materials at reduced costs, and of designing high efficiency sources of small size. The fiber crystals grown with this method can have a diameter between 0.1 and 1 mm and a length up to 50 cm. The furnace is similar to that for bulk crystals (fig. 1), but the fiber grows downward by pulling the seed that is in contact with the melt that comes out from a small orifice at the bottom of the crucible. Our furnaces are equipped with RF heating and can work at temperatures as high as 2000C. Fibers of various cristalline materials have already been grown, for example LiF, Si, YAl_5O_{12}, $NaLa(MoO_4)_2$ and $YAlO_3$ pure or doped with rare earths. All the grown crystals and fibers are then inspected for crystal and optical quality.

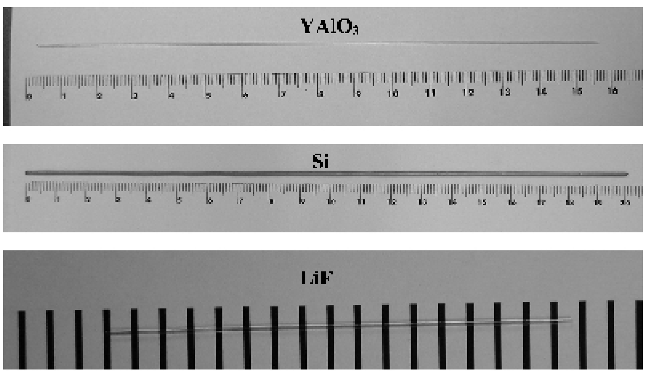

Fig. 1
Some examples of fibers grown with the micro-PD method.

Spectroscopy lab

Our group has long been working on insulating-crystal spectroscopy and their use as active media for solid state laser.

We focused our attention on the spectroscopy of oxide and fluoride samples, so in our laboratories we set-up a specially equipped apparatus in order to perform various types of measurements such as absorption and emission spectra, excitation spectra, pump and probe technique, and dynamical analysis of the fluorescence to calculate the absorption and emission cross sections and determine the most probable laser transitions. The steady state and dynamical measurements can be performed as a function of the temperature of the sample between 10 and 300 K. As the efficiency of the solid state laser devices is strictly dependent on the energy transfer mechanisms (such as ESA and up-conversion) that take place among the ions inside crystals, it is worth studying their spectroscopic characteristics to evaluate the type and importance of the energy transfer mechanisms really taking place.

These type of activity lead to several publications dealing with the investigation of new promising laser materials [5,10-12,14], and, sometimes, even to new efficient laser results [16].

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