New Hosts for Transparent Ceramics

Description for the general public

The aim of the project is to obtain new polycrystalline powders doped with rare earth and transition metal ions, investigate their spectral properties, and make the best of these transparent ceramics.

Double perovskite structure were selected for investigations. The structure of these compounds has unique properties, some scientists predict that the 21st century will be the perovskite era. In the first stage of the project we will synthesize the new matrices Ba_2MgWO_6 (BMW) and La_2MgTiO_6 (LMT), than we will prepare solid solutions of these two host with different proportions. These hosts are almost unexplored, in terms of spectroscopic properties. So far, less than 20 papers have been published, mainly on the study of crystallographic structure, and few theoretical work has also been published. These hosts area a real terra incognita on the map of new photonic materials. BMW has a cubic structure, LMT is orthorhombic. The cation point symmetries in this first compound are very high, the second much lower. It is well known that the spectral properties strongly depend on the symmetry of the local dopant. Ions placed in lower symmetry positions emit higher emission radiation compared to ions located in the structure in high symmetry positions. During the project, BMW will be mixed with LMT in such proportions to maintain the cubic structure, but locally within the matrix the point symmetry of the dopant's position will vary with amount of LMT. In this way, it will be possible to investigate the effect of local symmetry on the spectral properties of BMW.

Highly symmetrical systems are easier to describe and to model, in addition to experimental research, theoretical calculations from the first principles will be carried out to build and develop tools that will allow us calculating new structures and predict their properties before they are obtained.

Detailed spectroscopic studies will select the BMW-LMT solid solutions that will be characterized by intense and efficient luminescence. Then we will start work on making high quality ceramics. It is easiest to obtain transparent ceramics from regular crystallites. Since ceramics are pressed small crystals (grains) of micrometers to nanometers, only the perfect cubes will be able to fit so well that there will be no imperfections at the grain boundaries or the empty spaces between the grains. Made of cubic structure, the ceramic will reach ideal parameters, have a high density, high transparency and, in many applications, may be preferable to single crystals.

Transparent ceramics now replace crystals in photonics and optoelectronics. It's because it's easier to prepare large ceramics than large crystals, it’s less time consuming and cheaper, it's easier to mass-produce ceramics, and they can be doped much more homogeneously than crystals and will accept much more admixtures.

Ceramics are needed to build lasers, filters, and windows for UV or IR radiation, bulletproof glass, quantum memory, optical fibers, lighting and many more. The best-of-the-range YAG and Spinel ceramics cannot meet all of these requirements. Such extensive use of ceramic materials shows that it is necessary to look for new materials that will allow for manufacturing transparent ceramics to be used in photonics. Therefore, it is necessary to synthesize new materials and carry out basic research in order to investigate their properties. If the results obtained will be promising then this basic research will be able to be extended in the future for specialized application research.