Description for general public

Insight into electronic, structural and photoluminescent properties in selected Ce^{3+}, Bi^{3+}, Pr^{3+}-doped compounds through high pressure spectroscopy

Lanthanide and transition metal ions doped luminescent materials have received considerable attention for long time from a scientific viewpoint, and more recently also their enormous potential as new functional materials. The ability to precisely predict and control the luminescent properties of lanthanide and transition metal systems has long been an objective of the optical materials community. Solar energy conversion, biosensor, solid state lasers, optical data storage and phosphors are good examples of areas where precise control over the wavelength, lineshape, and efficiency of photoluminescence is essential for optimizing performance and extending the range of applications.

The design of luminescent functional materials for new applications requires a systematic understanding of the relationship between the local bonding environment of lanthanide and transition metal centers and their luminescence properties. The customary approach for discovering the relationships is to change the chemical composition of the host matrix. By changing chemical composition, it is possible to systematically adjust the local bonding environment of luminescence centers and further gain information useful in new materials design. However, variations in chemical composition, on the contrary, produce discrete changes, such as impurities and defects.

In this project, the alternative approach based on using hydrostatic pressure will be used to systematically influence the surrounding luminescence centers instead of changing chemical composition of the host. High pressure can lead to changes of crystal field and further result in the change of luminescence property of lanthanide and transition metal ions doped materials. This finer resolution is especially beneficial for investigating the properties of materials near boundaries corresponding to abrupt changes in properties (e.g. at crossover points of electronic energy levels, phase transitions, or resonance of dopant states with conduction band edges). Furthermore, high pressure provides the potential for achieving structures, molecular configurations, phases and electronic states that are not achievable through other means. Our group has an extensive experience in using and interpreting the high pressure spectroscopy technique. In the project, three group of important luminescence materials were selected high pressure studies. Various types of high pressure experiments will be performed in order to confirm our crucial hypothesis based on our preliminary results. The theoretical methods of the exchange-charge model (ECM), configuration coordinate model (CCM) and Birch-Murnaghan equation of states (EOS) will be applied for modeling the crystal field parameters (CFPs), energy levels and absorption spectra of rare earth ions.

The aim of this project is to investigate the influence of high pressure on the basic properties of d-d, d-f, f-f, and charge transfer transition in selected transition metal (Bi^{3+}) and lanthanide (Ce^{3+}, Pr^{3+}) doped systems. We do believe that our research will provide a new approach to better understand the relationship between the bonding environment of the luminescence centers and their electronic, structural and optical properties through high pressure spectroscopy. Our research will also offer a keen insight into the nature of the process of luminescence quenching mechanism crucial for achieving user-designed optical properties of the materials. This objective benefits not only new functional luminescence materials, but also allows us to better understand the ability of high pressure spectroscopy to function as probes of electronic structure and luminescence properties of lanthanide and transition metal systems.