

Currently, many technological processes require for proper execution the presence of functional materials characterized by strictly defined properties. Processes based on catalysis, water splitting technologies and lighting technologies among many others use systems consisting of an inorganic matrix and active centers in many different oxidation states incorporated into the matrix. Owing to the invaluable properties of the systems containing active centers in various oxidation states, research and development of such systems is becoming highly desirable. Considering that not only the mere presence of luminescence centers in various oxidation states, but also the ratio between the concentrations of these centers affects the properties of the aforementioned systems, the redox processes (oxidation and reduction) that lead to the formation of active centers must be conducted very carefully. Unfortunately, there is still a serious shortage of methodical research that could provide an answer as to what conditions must be satisfied for the reduction process in solid state to take place selectively.

The aforementioned systems are important in lighting technologies because they enable the application of cheap light sources based on white light emitting diodes (WLED) in manufacturing. Basically, a white light source is obtained by physically mixing a few phosphors exhibiting blue, green and red emissions in an appropriate weight ratio. Such a procedure is ineffective and can be replaced by a synthesis of a system consisting of a matrix activated by lanthanide ions in two different oxidation states (e.g.  $\text{Eu}^{2+}/\text{Eu}^{3+}$ ). From the technical perspective, obtaining such systems requires strict control of the reduction process which usually takes the form of controlling the duration of the process. However, the control of the duration of the reduction process is quite imprecise as far as obtaining a strictly defined ratio of the two oxidation states of a dopant is concerned.

The most recent research shows that the precise control can be achieved by aliovalent co-doping of a matrix - lanthanide system. These co-dopants can be considered compensators for the charge of  $\text{Ln}_{\text{Me}}^{\bullet}$  defect and, thus,  $\text{Eu}^{3+}$  stabilizers. Some results concerning stabilizing conditions of a given oxidation state of lanthanides indicate that the reduction process is related to the elimination of a previously formed compensator of  $\text{Ln}_{\text{Me}}^{\bullet}$  defect, for example a metal vacancy, from the immediate vicinity of the reduced lanthanide ion. This means that the more stable the compensator, the more stable  $\text{Eu}^{3+}$  ion under reductive conditions. The compensation of the charge related to  $\text{Ln}_{\text{Me}}^{\bullet}$  defect can be eliminated either by forming another defect (a secondary compensator) in the vicinity of the primary compensator, which will compensate the remaining negative charge after the reduction, or by physically removing the compensator via its migration in the crystal lattice from the reduced ion to the crystal surface. In order to describe both options, it is necessary to consider the influence of the diffusion process on the elimination of the primary compensator during the lanthanide reduction.

The aim of the methodical research undertaken within the scope of the proposed project is to explain the influence of the diffusion process of chemical species in solid state on the reduction process of the lanthanides incorporated into an inorganic matrix. A series of syntheses of systems consisting of oxide matrices doped with europium ions and aliovalent substituents is planned during the project. A number of syntheses, conducted with different methods, is proposed for a given system in order to investigate the impact of the synthesis method on stabilizing properties of the aliovalent substituent in question. All materials obtained during the project are going to be examined by X-Ray diffraction method (XRD) in order to qualitatively and quantitatively establish the phase composition of syntheses products.

Standard optical spectroscopy methods will include measurements of luminescence emission and excitation spectra as well as luminescence kinetics. Advanced spectral characterization methods, whose aim is to determine the location of energy states of a dopant and a substituent in the studied system, will be based on the measurements using additional variable parameters (e.g. temperature). Luminescence kinetics measurements will help determine the activation energy of energy transfer processes between the energy states of the europium ions in two oxidation states and the energy states of the co-dopant and the conduction band. Additionally, they will also enable determination of the compensating defects interaction range.

As the reduction process in these systems is usually considered to be an electric charge transfer from the reducing agent to the lanthanide ion, it is expected that the results of this project will verify the hypothesis that the elimination of the compensating defect is necessary for the reduction of a lanthanide to take place. If the obtained results support the hypothesis, then the conclusions from the study will play an important role in better understanding of the reduction process mechanism in the solid state and in the long run will enable designing more advanced luminescent systems.