The development of substitutional solid solutions is one of the ways to search new materials with required and specified properties. An advantage of a solid solution is a potential to change its physical, mechanical, or electronic properties in comparison with its components. For example, a development of solid solutions based on a well-known phosphor YVO₄ can improve its luminescence properties. The improvement may be due to a non-linear effect of the increase of the efficiency of excitation energy conversion into luminescence, which is observed in solid solutions [1].

For a successful synthesis of solid solutions the following Goldschmidt rules should be fulfilled: (i) the ionic radii of substitutable elements should differ no more than 15% and (ii) the charge of the substitutable ions may differ by a unity when eletroneutrality is achieved by pairwise substitution. The lattice parameters of successfully synthesized solid solutions follow Vegard law, which states that lattice parameters of a solid solution usually vary linearly with gradual substitution of components of the solid solution. The main goal of this work is the determination of the impact of annealing procedure on the formation of vanadate solid solutions, and also the study of dependence of the luminescence intensity on the crystal structure and composition of the vanadate solid solutions.

Synthesis of the vanadate LuxY₁₋ₓVO₄ solid solutions (x=0, 0.1, 0.3, 0.5, 0.7, 0.9, 1), undoped and doped with 1 mol% of Eu³⁺, were carried out by solid state method using H₃BO₃ as a flux. A stoichiometric amount of Lu₂O₃, Y₂O₃, Eu₂O₃ and V₂O₅ and 1 wt% of H₃BO₃ were thoroughly mixed and ground in an agate mortar. The mixtures were air heat-treated either (i) three times at 1000 °C, 1000 °C and 1200 °C for 2 hours with intermediate grindings or (ii) only once at 1200°C for 2 hours in air. The structure and morphology of the solid solutions were studied by scanning electron microscopy (Hitachi S-3400 N) and X-ray powder diffraction analysis (Bruker D8 Advance Diffractometer). It was concluded that all of the solid solutions were homogenous and crystallized in tetragonal system, I₄₁/amd space group. It is noteworthy that the lattice parameters, intensities of the diffraction lines, and residual color of the vanadates change with increasing synthesis temperature and depend on the preparation procedure. The experimental data have proved that heat-treatment at 1000 °C is sufficient to make YVO₄ and LuVO₄ powders, while the LuxY₁₋ₓVO₄ solid solutions require preparation at 1200 oC to achieve good crystallinity.

A relative intensity of X-ray luminescence depends on the synthesis procedure and the phosphors composition as well. The most efficient luminescence was detected for intermediate compositions of the solid solutions. The maximum of luminescence intensity for the LuxY₁₋ₓVO₄ with x = 0.7 and for the LuxY₁₋ₓVO₄:Eu³⁺ with x=0.3 and x = 0.7 at 300 K were observed. This effect is explained by the limitation of distance between the thermalized charge carriers in the solid solution.