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Spectroscopy of the Sm^{3+} ions in vanadate nanoparticles with various crystal lattice structures

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Vanadate materials exhibit unusual magnetic, optical, photocatalitic and luminescent properties those have very important applications in various fields. In particular, the RE-doped vanadates were considered recently as effective luminescent down-shifting materials for enhancement of solar energy harvesting by Si solar cells. This application requires compounds with improved efficiency of luminescence excitation under light from near UV and violet spectral ranges. The most attention in this search was paid to investigation of Eu-activated vanadate compositions.

In this work we investigate properties of Sm-activated vanadate nanoparticles as possible materials for the developed luminescent light transformers. Various concentration row sets of Sm-doped vanadate nanoparticles with $La_{1-x}Sm_xVO_4$, $La_{1-2x}Sm_xCa_xVO_4$ and $Sm_{1-x}Ca_xVO_4$ ($x < 0.3$) compositions were synthesized by sol-gel and co-precipitation methods. XRD study has shown that synthesized samples have monoclinic or tetragonal zircon structure as well as their mixture dependently on Sm and Ca concentrations. Characterization of the samples morphology made using scanning electron microscope Tescan Mira 3 LMU with 1 nm electronic beam diameter have shown that each sample consist of nanoparticles of the same diameters, but these diameters are varied from 40 nm to 200 nm for different compositions.

Luminescence properties also depend on concentrations and excitation wave length as well. At least two types of Sm^{3+} centers were found by emission spectra. These centers have different excitation efficiency by light from the 350 – 450 nm spectral range. Structures of the centers are discussed taking into account crystal structure, possible defects, morphology of the synthesized nanoparticles and surface effects. Influence of method of synthesis on emission intensity and structure of the spectra was observed and studied. Synthesis conditions and dopants compositions giving nanoparticles with the best characteristics for the above mentioned light down-shifting applications are reported.