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Development of High-Efficiency Down-Conversion Fluoride Phosphors to Increase the Efficiency of Solar Panels

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Abstract : Increase in the share of electricity received by conversion of solar energy results in the reduction of the industrial impact on the environment from the use of the hydrocarbon energy sources. One way to increase said share is to improve the efficiency of solar energy conversion in silicon-based solar panels. Such efficiency increase can be achieved by transferring energy from sunlight-insensitive areas of work of silicon solar panels to the area of their photoresistivity. To achieve this goal, a transition to new luminescent materials with the high quantum yield of luminescence is necessary. Improvement in the quantum yield can be achieved by quantum cutting, which allows obtaining a quantum yield of down conversion of more than 150% due to the splitting of high-energy photons of the UV spectral range into lower-energy photons of the visible and near infrared spectral ranges. The goal of present work is to test approach of excitation through sensibilization of 4f-4f fluorescence of Yb3+ by various RE ions absorbing in UV and Vis spectral ranges. One of promising materials for quantum cutting luminophores are fluorides. In our investigation we have developed synthesis of nano- and submicron powders of calcium fluoride and strontium doped with rare-earth elements (Yb: Ce, Yb: Pr, Yb: Eu) of controlled dimensions and shape by co-precipitation from water solution technique. We have used Ca(NO3)2*4H2O, Sr(NO3)2, HF, NH4F as precursors. After initial solutions of nitrates were prepared they have been mixed with fluorine containing solution by dropwise manner. According to XRD data, the synthesis resulted in single phase samples with fluorite structure. By means of SEM measurements, we have confirmed spherical morphology and have determined sizes of particles (50-100 nm after synthesis and 150-300 nm after calcination). Temperature of calcination appeared to be 600°C. We have investigated the spectral-kinetic characteristics of above mentioned compounds. Here the diffuse reflection and laser induced fluorescence spectra of Yb3+ ions excited at around 4f-4f and 4f-5d transitions of Pr3+, Eu3+ and Ce3+ ions in the synthesized powders are reported. The investigation of down conversion luminescence capability of synthesized compounds included measurements of fluorescence decays and quantum yield of 2F5/2-2F7/2 fluorescence of Yb3+ ions as function of Yb3+ and sensitizer contents. An optimal chemical composition of CaF2-YbF3- LnF3 (Ln=Ce, Eu, Pr), SrF2-YbF3-LnF3 (Ln=Ce, Eu, Pr) micro- and nano- powders according to criteria of maximal IR fluorescence yield is proposed. We suppose that investigated materials are prospective in solar panels improvement applications. Work was supported by Russian Science Foundation grant #17-73- 20352.

Keywords : solar cell, fluorides, down-conversion luminescence, maximum quantum yield
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