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Abstract

Energy conversion and quantum cutting mechanisms in selected inorganic compounds co-doped with Pr^{3+} or Yb^{3+} ions

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The downconversion is a process of emitting two or more photons of smaller energies preceded by absorption of one higher energy photon. This phenomenon is induced by interaction with the optically active material and is manifested through change of emitted radiation wavelength, often more useful for potential applications. For example, applying material with such feature to the photovoltaic Si cells is considered as an approach to reduce losses caused by thermalization of charge carriers, present when high energy photons are directly absorbed by cell. Downconversion phenomenon is meant to have direct impact on efficiency increase, not only in photovoltaics, but also in laser or imaging technology. Due to specific energy levels structure, weakly dependent on the strength of crystal field, lanthanide ions are great candidates for investigation on energy downconversion. However, the studies on downconversion still have not been systematically conducted - further materials showing energy downconversion are sought by the trials and errors method, the state of knowledge is quite modest, the methodology is not uniform, and the fragmentary research conducted so far is not free from cognitive gaps as well as from conceptual and methodology limitations.

Therefore, the research carried out in the frame of this dissertation is an attempt to systematize and expand the current state of knowledge about materials showing energy downconversion and about mechanism itself. This goal was achieved through the conscious selection of crystal matrices, where representatives of the inorganic optical materials classes were selected: silicates - $Y_2Si_2O_7$, phosphates - $RbLaP_4O_{12}$ and $LiLaP_4O_{12}$, fluorides - SrF_2, as well as dopant ions Pr^{3+} and Yb^{3+} with their co-dopants. The next step was to carry out a detailed analysis of their crystal structure, morphology and finally spectroscopic properties, including impact of the parameters that may affect the efficiency of the energy downconversion phenomenon. Recognition of the most significant of them was one of the goals of this dissertation. Additionally, based on obtained experimental results, new idea of downconversion sensitization by carbon dots was presented for the first time. The obtained results, apart from the fundamental conclusions allowing for the generalization to a larger class of materials, may make a significant contribution to the field of designing and manufacturing new materials with desired optical properties.