Ln(III)-Doped Hierarchically Nanostructured Y_2O_3 Nanoparticles for White Light Emission

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Recent studies of materials with white light emission for applications in solid state lighting have focused on improvement of several characteristics like emission efficiency, color resolution, durability, and stability, among others. In this work the properties of Y_2O_3, such as high thermal and chemical resistances, large band gap, low phonon energy and low toxicity were combined with the photophysical properties of emissive Ln(III) ions, such as narrow emission lines in the visible and long lifetimes, in order to obtain white light emission. Using the method of impregnation-decomposition cycles (IDC), which combines a layer-by-layer growth with the use of a porous silica host for controlled nanoparticle growth, Y_2O_3 nanoparticles were synthesized with hierarchically alternated pure and Ln(III)-doped (Ln(III) = Eu(III), Tb(III) or Tm(III)) layers, in order to prevent energy transfers between the Ln(III) ions and balance their emissions intensities. The nanoparticles are spheroidal, highly dispersed within the porous silica, with an average size of 4-5 nm after 13 IDC and have cubic crystal structure regardless of doping. Photoluminescence spectroscopy has shown broad PVG emissions in the range of 400-500 nm, and narrow emission bands attributed to Tb(III) $^5D_4 \rightarrow {}^7F_{6\text{-}4}$ and Eu(III) $^5D_0 \rightarrow {}^7F_{0\text{-}4}$, which combined resulted in a purplish-white emission. With λ_{exc} = 260 nm an increase in relative intensity was observed for Eu(III) emissions with the doped layer closer to the core of the nanoparticle, shifting the final emission from purplish-white to magenta. With λ_{exc} = 350 nm only PVG and Tb(III) emissions were observed, and with λ_{exc} = 393 nm only PVG and Eu(III) emissions were observed, indicating that there is no Tb(III)→Eu(III) energy transfer. From excitation spectra and emission lifetime measures energy transfers were not observed between Ln(III) ions or between those and the porous silica host.

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