Synthesis and characterization of down-conversion nanophosphors

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Among the forms of green energies (e.g. hydropower, wind power, geothermal power and biomass) solar power is one of the most sustainable energy due to its abundance and renewability. Using the photovoltaic (PV) effect, sunlight can be converted directly into electricity. However, the classical efficiency limit of silicon-based solar cells is currently estimated to be 29%, and detailed-balance calculations show that this number could be improved up to approximately 37% using spectral modification. There are three spectral modification methods in place to be used, namely; downconversion (DC), photoluminescence (PL) and upconversion.

Shalav et al. suggested that light with energy lower than the threshold of ~1.25 eV would be suited for upconversion (UC), whereas light with energy higher than the threshold of ~ 1.25 eV would be better suited for downconversion (DC) applications for an ideal semiconductor with a threshold of ~ 1.35 eV. The possibility of achieving two-photon emission via energy transfer was first predicted by Dexter. Now the research of DC is focused mainly on the RE (Tb^{3+} −Yb^{3+}) ion pairs. However, several issues have not been solved yet: the f-f transition which leads to a narrowband excitation and the very low energy transfer efficiency from Tb^{3+} to Yb^{3+} since the Tb^{3+} ions show weak absorption in the UV/blue region due to the forbidden nature of 4f−4f transitions.

In this study, we focus more on investigating downconversion process on the Ce^{3+} −Tb^{3+} couple in the compounds $ZnAl_2O_4$ and SiO_2. One of the advantage for the use of Ce^{3+} ions is due to the fact that the transition of Ce^{3+}: 4f →5d has relative strong absorption at the wavelengths less than 350 nm unlike Tb^{3+} ions which shows a weak absorption in the UV/blue region. The investigation of the downconversion phenomena is mainly focuses on the evaluation of an efficient energy transfer between Ce^{3+} and Tb^{3+} ions. Here, Ce^{3+} ions will be classified as sensitizers by absorbing UV photons and through energy transfer where Tb^{3+} ions will then be classified as activators responsible for the output of the visible emission. In principle, downconversion is a process where a high energy photon is converted into several lower energy photons with energies above the band gap of the luminescent material (phosphor).

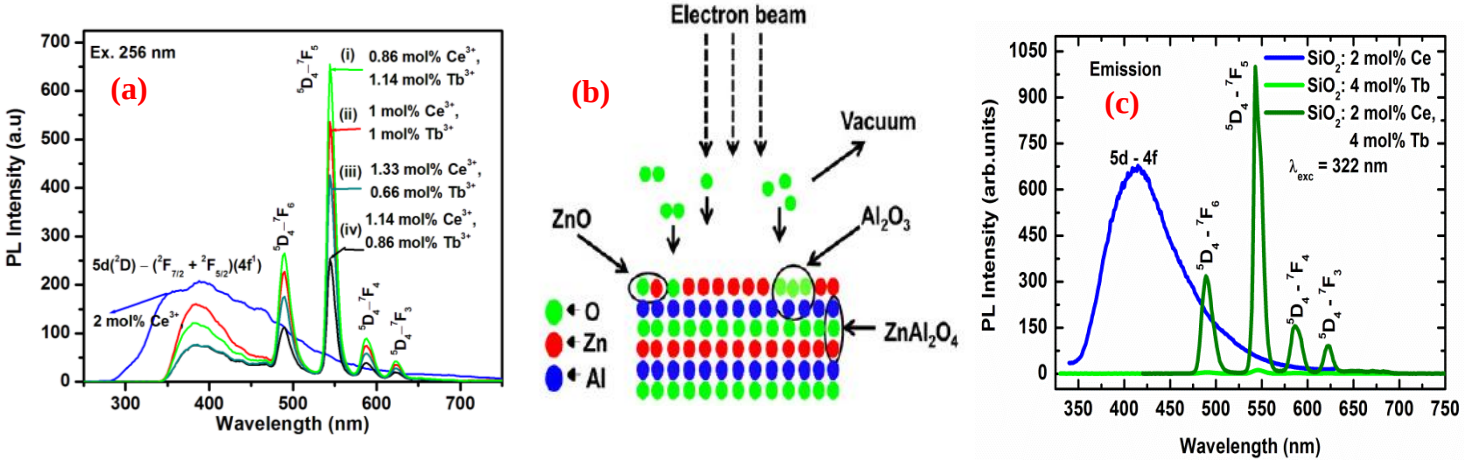

Figure 1. (a) PL emission of singly doped ZAO:Ce and co-doped ZAO:Ce,Tb (b) the ESSCR for chemical reaction on the surface of ZAO:Ce,Tb (c) PL emission of singly doped SiO_2:Ce, SiO_2:Tb and SiO_2:Ce,Tb