Performance enhancement of dye sensitized solar cells using down/up-conversion nanoparticles

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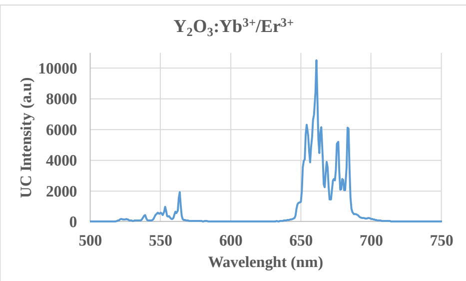
Dye sensitized solar cells (DSSC) generally use visible light for photo-electric conversion. In a DSSC, light absorption is conducted by a light sensitive dye. The ability of the dye to capture light in a wide band range of the light spectrum determines the conversion efficiency of the DSSC. The currently employed dyes in DSSC with the highest conversion efficiencies (N-719) have a light spectrum absorption range of 300-730 nm [1]. Consequently, the inability of these dyes to absorb ultra violet light (UV) and infrared (IR) light, which makes up to 52% of energy of the entire solar spectrum, forms the main energy loss mechanism of DSSC. To realize photo-current conversion from these light, rare-earth luminescent phosphors, which have large band gap, high refractive index, low phonon energy and chemical stability at high temperatures, are promising to circumvent the photon transmission losses [2]. This technology is expected to enable single junction photovoltaic cells break the Shockly-Queisser limit.

A facile urea based homogeneous precipitation method was employed for the fabrication of both up-converting (UP)(Y_2O_3:Er^{3+}/Yb^{3+}) and down-converting (DC) (Y_2O_3:Tb^{3+}/Eu^{3+}) nanoparticles. DSSC was fabricated via the conventional doctor blade method. Firstly, transparent TiO_2 colloids mixed 1 wt % Y_2O_3:Er^{3+}/Tb^{3+} with colloids were deposited on the FTO glass to form a transparent photoelectrode. The samples were then sintered at 500℃ for 2 hours. The TiO_2 colloids) mixed with 10 wt% Y_2O_3:Yb^{3+}/Er^{3+} nanoparticles were subsequently screen-printed ontop of the first the TiO_2+ Y_2O_3:Er^{3+}/Tb^{3+} film. The photoanode was then soaked in the N-719 dye solution for 24 hours. Eventually the sandwich-type DSSC were fabricated with platinum-coated FTO glass and iodine electrolyte.

Figure 1(a) shows photoluminescence spectra of UC nanoparticles under laser diode excitation (λ=980 nm). We confirmed green and red light which corresponded to Y_2O_3:Er^{3+}/Yb^{3+} emission. **Figure 1(b)** shows photoluminescence spectra of DC nanoparticles under CW laser diode excitation (λ= 315 nm). We also confirmed both green and red light which corresponded to Y_2O_3:Eu^{3+}/Tb^{3+} emission. This indicates that the up/down converters we developed are capable of transforming UV/NIR into visible light thereby contributing to more photogeneration and have the potential for enhancement of photovoltaic performance of DSSCs. The details will be presented at the conference.

[1] B. O`Regan and M. Gratzel, Nature, 353, 737 (1991).

[2] Y. Shang, et al., Nanomaterials, 1782, 2079-4991, (2015).



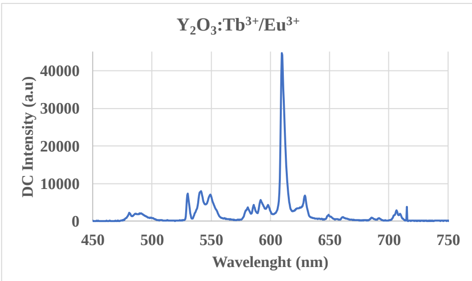


Fig. 1 Photoluminescence spectra of **(a)**UC and **(b)** DC nanoparticles.