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Quantum Confinement Effect Induced by Thermal Treatment of CdSe Adsorbed on TiO_2 Nanostructure

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It has been known that quantum confinement effect of CdSe nanocrystal was observed by increasing the number of deposition cycle using successive ionic layer adsorption and reaction (SILAR) method. Here, we report on thermally-induced quantum confinement effect of CdSe at the given cycle number using spin-coating technology. A cation precursor solution containing 0.3 M $Cd(NO_3)_2 \cdot 4H_2O$ is spun onto a TiO_2 nanoparticulate film, which is followed by spinning an anion precursor solution containing 0.3 M Na_2 $SeSO_3$ to complete one cycle. The cycle is repeated up to 10 cycles, where the spin-coated TiO_2 film at each cycle is heated at temperature ranging from 100°C to 250°C. The CdSe-sensitized TiO_2 nanostructured film is contacted with polysulfide redox electrolyte to construct photoelectrochemical solar cell. Photovoltaic performance is significantly dependent on the heat-treatment temperature. Incident photon-to-current conversion efficiency (IPCE) increases with increasing temperature, where the onset of the absorption increases from 600 nm for the 100°C- to 700 nm for the 150°C- and to 800 nm for the 200°C- and the 250°C-heat treatment. This is an indicative of quantum size effect. According to Tauc plot, the band gap energy decreases from 2.09 eV to 1.93 eV and to 1.76 eV as the temperature increases from 100°C to 150°C and to 200°C (also 250°C), respectively. In addition, the size of CdSe increases gradually from 4.4 nm to 12.8 nm as the temperature increases from 100°C to 250°C. From the differential thermogravimetric analysis, the increased size in CdSe by increasing the temperature at the same deposition condition is found to be attributed to the increase in energy for crystallization with dH= 240 cal/°C. Due to the thermally induced quantum confinement effect, the conversion efficiency is substantially improved from 0.48% to 1.8% with increasing the heat-treatment temperature from 100°C to 200°C.

Keywords: CdSe, quantum dot sensitized solar cell, spin coating, size quantization effect