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Optical and Photovoltaic Properties of CdSe Quantum Dot Sensitized Solar Cells Prepared with Different Cycles of Successive Ionic Layer Adsorption and Reaction

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Semiconductor quantum dots (QDs) have attracted significant interest in sensitized solar cells [1]. The semiconductor QDs, exploit as a sensitizer, have several advantages such as quantum confinement, large extinction coefficient, and multiple exciton generation [2]. To date, there have been a few applications of the Successive Ionic Layer Adsorption and Reaction (SILAR) process for preparation of CdSe QDs. In addition, a deposition of CdSe QDs by the SILAR method on inverse opal TiO_2 (IO-TiO_2) has not been reported.

We have studied the optical absorption properties of CdSe QDs adsorbed on IO-TiO_2 and nanoparticulate TiO_2 (NP-TiO_2) electrodes, including the photovoltaic properties of CdSe QDs sensitized solar cells (QDSSCs). CdSe QDs were grown on a IO-TiO_2 and NP-TiO_2 surface by a SILAR method for different cycles. Sandwich structure solar cell was consisted of Cu_2S on brass as a counter electrode and a polysulfide (S/S^{2-}) redox system as the electrolyte. The growing size of CdSe QDs on the TiO_2 electrodes with increasing cycles was confirmed by a redshift in the optical spectra, measured using photoacoustic (PA) spectroscopy (Fig. 1). The steepness factor was estimated from the PA spectrum. The steepness factor (σ) of CdSe QDs on IO-TiO_2 was lower than that on NP-TiO_2 below 7 cycles, indicating that the CdSe QDs on IO-TiO_2 produced more disorder and surface states than NP-TiO_2. Subsequently, the σ showed toward constant over 9 cycles due to the increasing CdSe QDs size and the aggregation of CdSe QDs. Fig. 2 shows the photocurrent versus voltage relationship for CdSe QDSSCs under an illumination of air mass (AM) 1.5. The maximum photovoltaic conversion efficiency (η) of CdSe QDs on IO-TiO_2 was 1.3% and that of CdSe QDs on NP-TiO_2 was 2.7%, prepared with 9 cycles. Lower η of CdSe QDs on IO-TiO_2 than that on NP-TiO_2 was possibly because of the lower adsorption of Cd^{2+} ions, a larger amount of surface states, and lower TiO_2 surface area. These results indicate that the CdSe SILAR cycle is the important condition that affects the photovoltaic properties of CdSe QDSSCs.

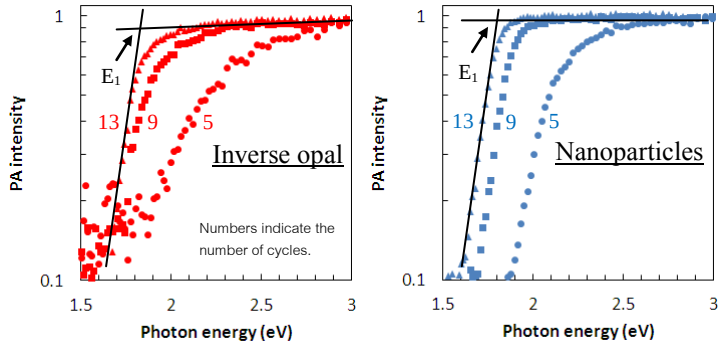

FIG. 1. PA spectra of CdSe QDs adsorbed on TiO_2

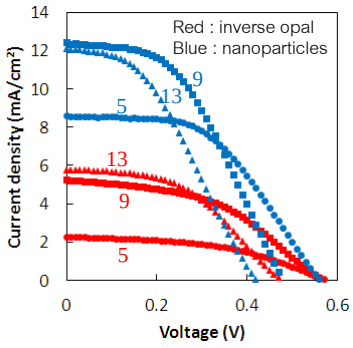

FIG. 2. J-V curve of CdSe QDSSCs.

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