Characterization of Optical Properties of Semiconductor Quantum Dot-Sensitized Solar Cells together with Ultrafast Carrier Dynamic Properties

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Semiconductor quantum dots (QDs) could be provided as a sensitizer for the sensitized solar cells [1,2] due to its adjustable energy gaps, large intrinsic dipole moment, and large extinction coefficient. Moreover, QD-sensitized solar cell has a capability of producing multiple exciton generation (MEG) [3]. We demonstrate CdSe QD-sensitized solar cells based on different kinds of nanostructured TiO_2 electrodes with (1) conventional assembly of nanoparticles, (2) nanotubes [4], and (3) inverse opal structure (photonic crystal) [2,5]. CdSe QDs were adsorbed on the nanostructured TiO_2 electrodes by chemical bath deposition [2,6]. Finally, the surface of electrodes were passivated by ZnS coating [7]. Sandwich structure solar cells were prepared by using the Cu_2S counter electrode [8]. Polysulfide solution was used as a regenerative redox couple. Optical absorption characterization was carried out with photoacoustic (PA) spectroscopy [9]. Incident photon to current conversion efficiency (IPCE) and photovoltaic properties were investigated. Photosensitization by CdSe QDs could be observed in the visible region. The maximum IPCE value of 75% and the maximum photovoltaic conversion efficiency of 3.5% can be obtained. These values are relatively high for semiconductor QD-sensitized solar cells. Photoexcited carrier dynamics is characterized with the improved transient grating (TG) technique [10, 11]. It depends on the refractive index change by photoexcited carrier population. TG measurements show the fast (hole) and slow (electron) relaxation processes with lifetimes of a few picosecond and a few tens to hundred picoseconds, respectively. There are correlations between the lifetimes of photoexcited carrier dynamics and the photovoltaic properties.

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