Photoacoustic and Photoelectrochemical Current Characterization on Nanostructured TiO_2 Electrodes made from Hydrolysis and Oxidation Processes for $TiCl_4$ together with CdSe Quantum Dots Adsorption

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Highly porous nanocrystalline TiO_2 has received much interest because of its strong role in applications such as photoelectrochemical solar cells and photocatalysis. For solar cell application, organic dye sensitization is one of the methods used to extend the photoresponse of TiO_2 electrodes to the visible region, where photoexcited electrons of the dye molecules are transferred to the conduction band of TiO_2. Recently, semiconductor quantum dots (QDs) are used as sensitizers to realize a more efficient solar energy conversion than that obtained by organic dye sensitization.[1,2)] The use of semiconductor QDs as sensitizers has some advantage in solar cell applications.[3)] Firstly, the energy gap of the QDs can be tuned by controlling their size to match the spectral distribution of sunlight. Secondly, the QDs have a large optical absorption coefficients, and intrinsic dipole moments leading to rapid charge separation. In this work, we report the CdSe QDs sensitization[4)] in nanostructured TiO_2 electrodes made from hydrolysis and oxidation processes for $TiCl_4$ characterized with photoacoustic (PA) and photoelectrochmical current characterization. Optical absorption can be characterized by PA method because it detects a signal directly proportional to the thermal energy by nonradiative processes in which optical absorption information can be involved. PA signal is less sensitive to light scattering effects and it is suitable for the TiO_2 electrodes concerned.

The SEM image of the TiO_2 electrode made from hydrolysis and oxidation processes for $TiCl_4$ in Fig. 1 shows high surface roughness and crevices in the film and the TiO_2 electrode consists of nanoparticles with an average diameter of 20 nm. Figure 2 shows the PA spectra of TiO_2 electrodes with CdSe QDs for different adsorption time. When the adsorption time was increasing, redshft of the PA spectra can be clearly observed. Relative to bandgap of bulk CdSe, the optical absorption shoulders in the PA spectra show blueshift, indicating the quantum confinement effects. Figure 3 shows the PEC spectra of the TiO_2 electrodes with CdSe QDs adsorption for different adsorption time. When the adsorption time was increasing, redshft of the PEC spectra can be clearly observed. The photosensitization of the TiO_2 electrodes in the visible region resulting from CdSe QDs adsorption can be observed. The PEC intensity depends on the adsorption time and shows a maximum around an adsorption time of 24 hours. Figure 4 shows the incident photon to current efficiency (IPCE) spectra of the TiO_2 electrode and that with CdSe QDs adsorption for 24 hours. IPCE value of the TiO_2 electrodes with CdSe QDs adsorption is around 35% in the visible region.

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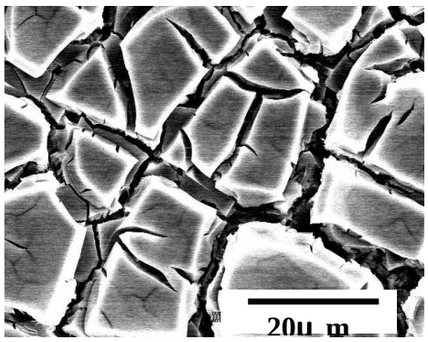

Fig. 1. SEM micrograph image of the TiO_2 electrode made from hydrolysis and oxidation processes of $TiCl_4$.

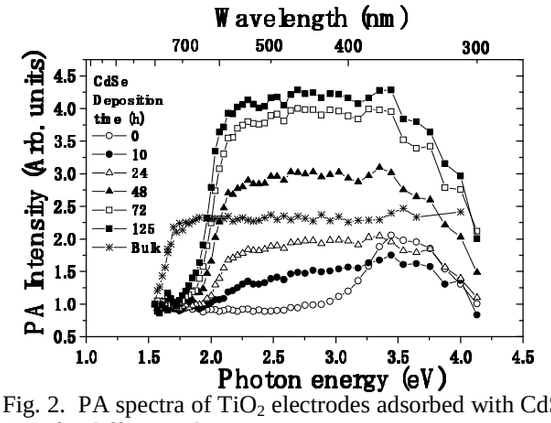

Fig. 2. PA spectra of TiO_2 electrodes adsorbed with CdSe QDs for different adsorption time.

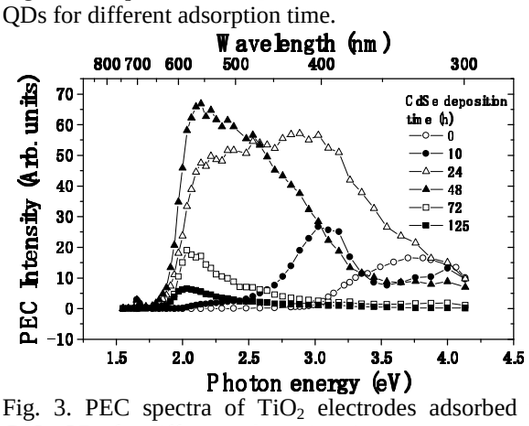

Fig. 3. PEC spectra of TiO_2 electrodes adsorbed with CdSe QDs for different adsorption time.

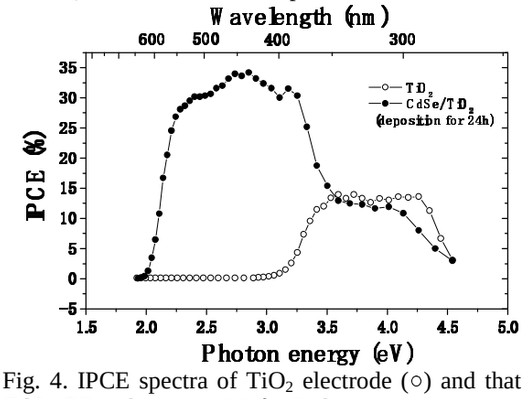

Fig. 4. IPCE spectra of TiO_2 electrode (○) and that with CdSe QDs adsorption (●) for 24 hours.

References

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