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Taro Toyoda

The University of Electro-Communications, Japan

Electronic structure of inverse opal- and nanoparticulate- TiO_2 electrodes

One of the main factors determining the photovoltaic performance in sensitized solar cell is the morphology of the TiO_2 electrode. Using a suitable morphology can lead to improvements in the photovoltaic conversion efficiency. The present study focuses on a comparison between the electronic structure of inverse opal (IO)- and nanoparticulate (NP)-TiO_2 electrodes. A higher open circuit voltage, V_{oc}, was observed with IO-TiO_2 electrodes compared to conventional NP-TiO_2 electrodes. It appears that fundamental studies are needed to shed light on the underlying physics and chemistry governing the enhancement of V_{oc}. Optical absorption measurements by the photoacoustic spectroscopy showed that indirect and direct transitions can be observed in IO- and NP-TiO_2. The indirect bandgaps of IO- and NP-TiO_2 are similar to each other (~ 3.2 eV) in good agreement with previously reported, and the direct bandgaps of them are ~ 3.6 eV and ~ 3.5 eV, respectively, indicating difference in the electronic structure. There is a possibility that the density of states in the conduction band of IO-TiO_2 is larger than that of NP-TiO_2. Analysis of the Urbach tail shows that there is a higher exciton-phonon interaction in IO-TiO_2 than in NP-TiO_2. Indirect photoluminescence (PL) and exciton PL can be observed. Also, PL due to oxygen vacancies was observed. The PL spectra suggest difference in the valence band structure between IO- and NP-TiO_2. The position of valence band maximum for IO-TiO_2 is higher than that for NP-TiO_2 measured by photoelectron yield spectroscopy, indicating that the surface of IO-TiO_2 is polarized with more positive dipole moment toward the vacuum level than that of NP-TiO_2. Hence, the formation of a double layer in the former is different from that in the latter due to the differences in the formation of oxygen vacancies, suggesting a correlation with the increased V_{oc} in sensitized solar cells.

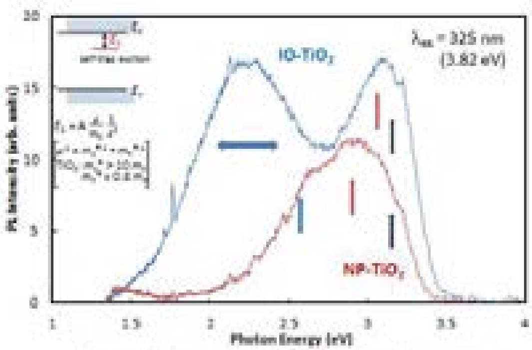

Figure 1: Photoluminescence spectra of inverse opal (IO)2 and nanoparticulate (NP)-TiO2 electrode.

Biography

Taro Toyoda has completed his DSc from Tokyo Metropolitan University and was a Research Associate at National Research Council of Canada (NRCC). He is now a Project Professor of The University of Electro-Communications. His research focuses on basic studies of optical properties in semiconductor quantum dots including photoexcited carrier dynamics and their applications to photovoltaic solar cells. He has published more than 200 papers in reputed journals.

toyoda@pc.uec.ac.jp