

## Supplementary Materials

Co-Sensitized Mesoporous TiO<sub>2</sub> Solar Cells: Hybrid Sensitizer of SILAR-Grown CdS Quantum Dot (QD) and Molecular Dye (Z907) with a Metal Oxide InterlayerJi-Young Oh, Dong Wook Chang,<sup>†,\*</sup> and Hyo Joong Lee<sup>\*</sup>

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## Experimental

**Chemicals and Reagents.** All chemicals were used as received. For SILAR growth of CdS, Cd(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O and Na<sub>2</sub>S were purchased from Sigma-Aldrich. Ethanol and Methanol were a HPLC grade from J. T. Baker. As a precursor for the thin metal oxide layer, aluminium isopropoxide (Al<sub>2</sub>O<sub>3</sub>), zirconium isopropoxide isopropanol complex (ZrO<sub>2</sub>), and tetraethyl orthosilicate (SiO<sub>2</sub>) were obtained from Sigma-Aldrich along with 2-propanol.

**TiO<sub>2</sub> Photoanode.** The FTO glass (2.2 mm, 8 Ω/sq.) was pretreated with TiCl<sub>4</sub> for 30 min., and then heated to 450 °C to make a thin blocking TiO<sub>2</sub> layer. Using screen-printing machine and commercial TiO<sub>2</sub> pastes, about 5 mm thick TiO<sub>2</sub>-blend layer (Dyesol, 18NR-AO; TiO<sub>2</sub> particle size 20-450 nm) which is responsible for adsorbing most of sensitizers in the electrode and ~4 μm scattering layer (Dyesol, WER2-O; TiO<sub>2</sub> particle size 150-250 nm) were deposited and then sintered upto 500 °C to make a mesoporous TiO<sub>2</sub> film. Finally, the typical TiCl<sub>4</sub>-posttreatment was applied.

**SILAR Process for CdS QD.** As for growing CdS QD sensitizer, the SILAR process was done by alternative dipping of as-prepared FTO/TiO<sub>2</sub> electrodes in ethanol solution of 50 mM Cd(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O and in methanol solution of 50 mM Na<sub>2</sub>S, respectively for 1 minute. Between dipping, a washing step was included for 1 minute in pure alcoholic solvent.

**Metal Oxide Layer.** The TiO<sub>2</sub>/CdS-modified FTO electrode was dipped for 10 minutes in each alcoholic solution of 15 mM precursor (aluminium isopropoxide and zirconium isopropoxide isopropanol complex dissolved in 2-propanol while tetraethyl orthosilicate in ethanol). Then, the TiO<sub>2</sub>/CdS/metal oxide precursor-modified electrode was taken out and dried in air for 1 minute. To make the expected hydrolysis reaction of the precursor layer to go more complete and for sure, the electrode was dipped in water for 1 minute and then dried in air for 1 hour before sensitized with Z907 dye.

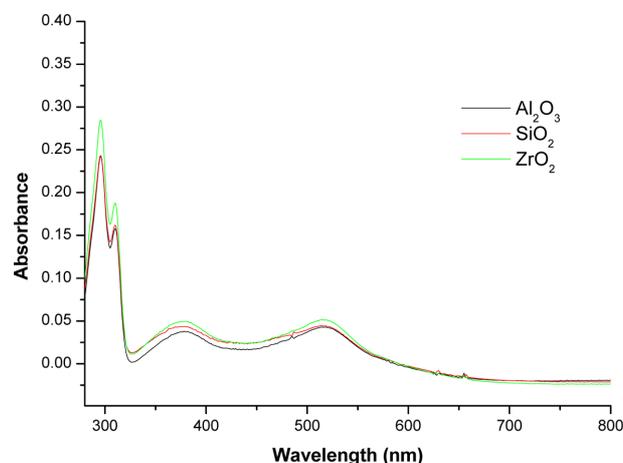
**Dye-sensitization.** The TiO<sub>2</sub>/CdS/Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, or SiO<sub>2</sub>-modified FTO electrode was dipped for 3 hours in 90 mM

Z907 dye solution in acetonitrile/*tert*-butanol (1:1, v/v) and then washed in pure solvent of ACN/*t*-BuOH (1:1, v/v).

**Cell-assembly.** To make CdS QD/ (Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, or SiO<sub>2</sub>)/Z907-sensitized solar cells with a counter electrode of the typical platinumized FTO glass, the as-prepared photoanode and cathode were combined by hot-press machine through the Surlyn film, and the electrolyte solution was injected through a pre-drilled hole through the counter electrode. The electrolyte was composed of 0.2 M Co(bipyridine)<sub>3</sub>(PF<sub>6</sub>)<sub>2</sub>, 0.05 M Co(bipyridine)<sub>3</sub>(PF<sub>6</sub>)<sub>3</sub>, 0.1 LiClO<sub>4</sub>, and 0.2 M 4-*tert*-butylpyridine in acetonitrile.

**Measurement.** The current-voltage measurements under standard illuminating condition (1 sun) were done using a solar simulator (Pecell, PEC-L01) and a potentiostat (IVIUM, Compactstat)

**Absorbance Measurement.** The adsorbed Z907 dye over a very thin metal oxide (Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, or SiO<sub>2</sub>)-modified TiO<sub>2</sub> film was detached by dipped and shaken in a mixed solution of 0.1 M NaOH in H<sub>2</sub>O/*tert*-butanol (3 mL/3 mL).



**Figure S1.** Comparison in absorbance of the Z907 dye detached from a very thin metal oxide (Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>, or SiO<sub>2</sub>)-modified TiO<sub>2</sub> film.