Electronic Supplementary Material (ESI) for Nanoscale

Supplementary Information

Dye-Sensitized Solar Cells Based on a Nanoparticle/Nanotube Bilayer Structure and Their Equivalent Circuit Analysis

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Calculation of the porosity of nanoparticle film and nanotube film

Nanoparticle:

The weight percentage of TiO_2 in the TiO_2 nanoparticle paste is 10%. There are 1 g of TiO_2, 1 g of poly(ethylene glycol), 4,44 g water and 3.56 g ethanol in 10 g solution. The volum of the solution is approximately 10 ml. Therefore the density of the paste is 1 g/cm^3, then the volume fraction of TiO_2 is $10\% \times \frac{1\ \text{g/cm}^3}{3.97\ \text{g/cm}^3} = 2.52\%$, where 3.97 g/cm^3 is the density of P-25 TiO_2 (75 % of anatase and 25 % of rutile, 75% x 3.88 + 25% x 4.23 = 3.97 g/cm^3

The height of paste before drying is equal to the thickness of spacer, i.e. 50 μm. After drying, the thickness of TiO_2 nanoparticle layer decreased to approximately 6 μm. This volume is 12% of the original volume (i.e., 6/50 = 12%). Therefore, the volume fraction of TiO_2 in the dried layer is $2.52\% / 12\% = 21\%$. So the porosity of TiO_2 nanoparticle film is about $100\% - 21\% = 79\%$.

Nanotube:

According to the SEM results, the nanotube has an outer diameter of 120 nm and an inner diameter of 90 nm. Assuming the nanotube is a nanocylinder. The total volume of nanocylinder is $V_{total} = \pi \times \frac{d_o^2}{4} \times h$. The volume of TiO_2 wall is $V_{TiO_2} = \pi \times \frac{d_o^2 - d_i^2}{4} \times h$. Then the volume fraction of TiO_2 is $\frac{V_{TiO_2}}{V_{total}} = \frac{d_o^2 - d_i^2}{d_o^2} = 1 - \frac{90^2}{120^2} = 0.44$. Therefore, the porosity of TiO2 nanotube film is about $100\% - 44\% = 56\%$.

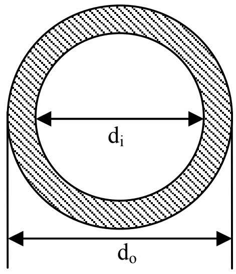

Table S1 Fitted parameters of J_0 and n of dye-sensitized solar cells.

Thickness (μm)			J_0 ($\mu A/cm^2$)	n
Total	Nano-particle	Nano-tube		
13	13	0	101.3	7.18
13	6	7	1.71	3.66
20	20	0	99.0	6.20
20	13	7	46.5	5.25
20	6	14	3.71	3.58
26	26	0	19.0	5.11
26	20	6	14.4	4.46
26	13	13	0.65	3.14