**Dye-Sensitized Solar Cells using Semiconductor Thin Film Composed of Ceramic Nanotubes**

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We present efficient dye-sensitized solar cells, which show high short-circuit photocurrent densities especially in the thin film thickness region, using mono-crystalline titania and zinc oxide nanotubes as the semiconductor thin film of dye-sensitized solar cells.

We succeeded in preparation of a mono-crystalline titania nanotubes with high photo-catalytic activity. These titania nanotubes with high aspect ratio facile electron transfer through titania thin layer due to extremely decrease in the contact number among nanotubes in comparison with that of nanoparticles.

Titania nanotubes were characterized by transmission electron microscopy (TEM) images, together with electron diffraction, X-ray diffraction and nitrogen adsorption isotherms. A TEM image of the calcined sample shows lattice images of anatase crystal, which clearly shows that nanotubes are mono-crystals of anatase. The electron diffraction pattern also shows that nanotubes are crystals of anatase.

Figure 2 shows an example of photocurrent-voltage characteristics of a cell made of the titania nanotubes. The film thickness was 4 μm, and the cell size was 0.5 cm × 0.5 cm. The obtained short-circuit photocurrent density was 15.3 mA/cm$^2$, and the open-circuit voltage was 0.58 V. The light-to-electric energy conversion yield was 4.88 %, and the fill factor was 0.54.

Figure 3 shows the short-circuit photocurrent density obtained from the cells made of titania nanotubes, together with those of P-25, against the film thickness. In the thin film region, the photocurrent density of the cell made of titania nanotubes was more than 2 times higher than the cell made of P-25.

A dye-sensitized solar cell made of zinc oxide also shows high short-circuit current density in comparison with the cell made of commercially available zinc particles.

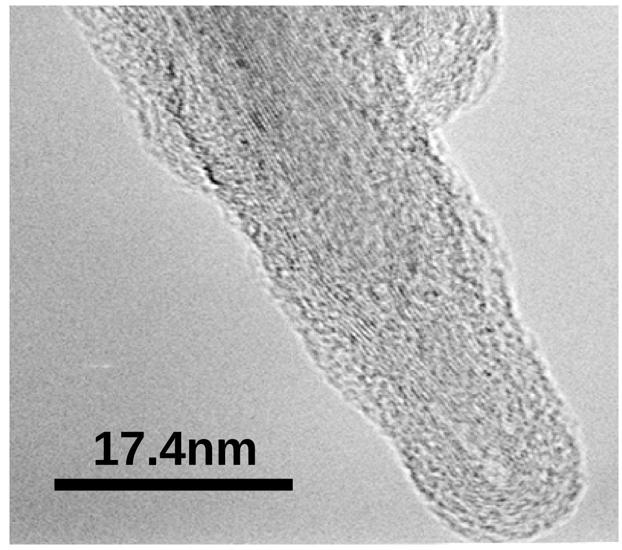


Figure 1. TEM image of the calcined sample of titania nanotubes.

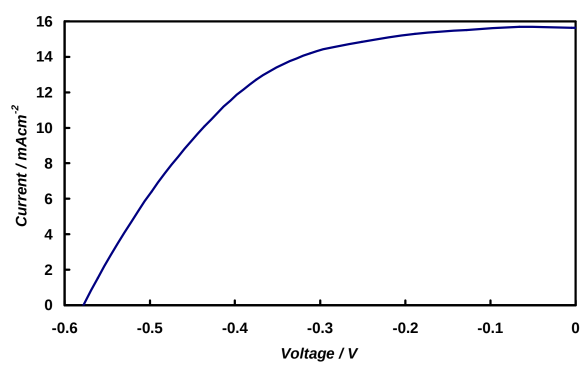


Figure 2. An examplee of photocurrent-voltage characteristics of a cell made of titania nanotubes.

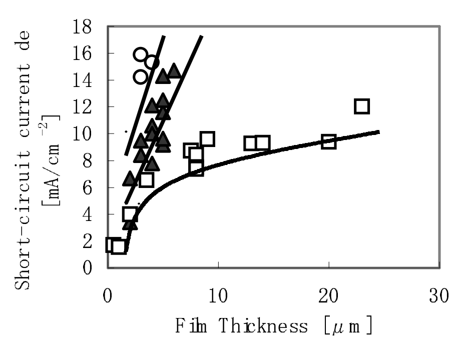


Figure 3. Relationship between the short-circuit photocurrent density and the film thickness.

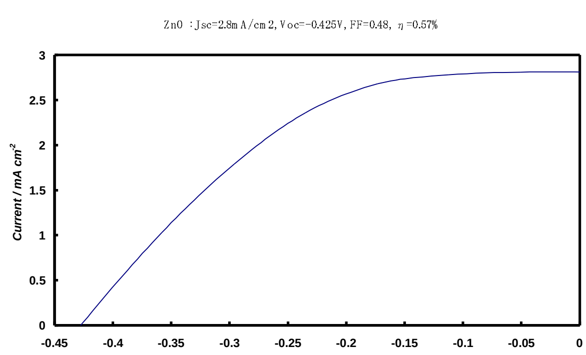


Figure 4. Current-voltage relation of a cell made of ZnO.