ELECTROPHORETIC DEPOSITION OF AG NANOPARTICLES INTO TIO_2 NANOTUBE ARRAYS AND THEIR PERFORMANCE AS PHOTOANODE OF DYE-SENSITIZED SOLAR CELLS

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Dye-sensitized solar cells (DSSCs) are known as next-generation solar cells because their production process costs low and is environmentally friendly compared to silicon-type solar cells, which are currently most widely used in the world. However, power conversion efficiency (PCE) of DSSCs is still lower than 12%, which is much lower than that of silicon-type solar cells. Since one of the main reasons of such a low PCE of DSSCs is a weak light absorption ability of dye molecules, researchers have been studying to improve the light harvesting ability of DSSCs by, for instance, producing new dyes, designing new DSSC structures, adding light absorbing/scattering elements/materials, etc. The addition of metal nanoparticles (NPs) to an photoanode is one of the ways to improve light harvesting ability of DSSCs, because the NPs exhibit surface plasmon resonance (SPR) which absorb and scatter light strongly. SPR is a collective oscillation of free electrons of metal, thus strong electro-magnetic (EM) field is created near the surface of metal NPs. The electrons of dyes can be easily excited by the enhanced EM field and thus the PCE of DSSCs improved. However, the improvement of PCE of DSSCs by metal NPs is generally not as high as expected, because it is difficult to control dispersion state of metal NPs in an photoanode.

In this work, Ag NPs were used as metal NPs because Ag NPs are known to create the strongest EM field by SPR among all metals. Anodic TiO_2 nanotube (TNT) arrays were employed as a photoanode since the morphology of TNT arrays is known to be appropriate to reduce an electrical resistivity at photoanode. Several methods of Ag NP deposition on TNT arrays were investigated for controlling the dispersion state of Ag NPs.

Ag NPs were found to be deposited only on the upper side of TNT arrays when they were deposited through photo-reduction of Ag ions or electrophoretic deposition (EPD) of Ag NPs with DC current. On the other hand, Ag NPs were homogeneously deposited throughout nanotubes when they were deposited by electrophoretically with DC accompanied with AC current. DSSCs with Ag NP-deposited TNT arrays showed the highest PCE of 5.01% which was 35% higher than DSSCs without Ag NPs.

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[1] X. Wei, P. Nbelayim, G. Kawamura, H. Muto, A. Matsuda, Ag nanoparticle-filled TiO_2 nanotube arrays prepared by anodization and electrophoretic deposition for dye-sensitized solar cells, accepted for publication in Nanotechnology.

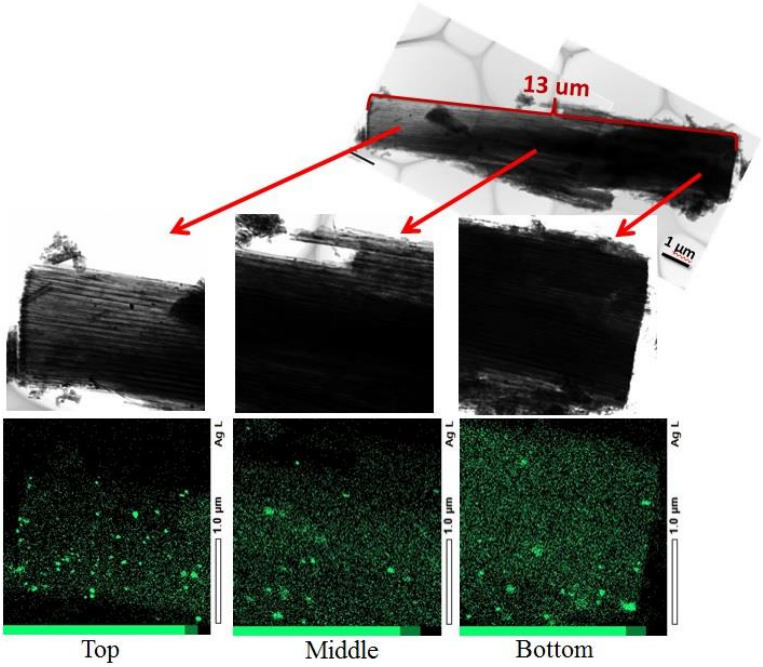

Fig. 1 STEM-EDX observations of Ag NP-deposited TNT arrays. The EDX images show the positions of Ag NPs.