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# A New Strategy to Fabricate a Colloidal Array Templated $TiO_2$ Photoelectrode for Dye-sensitized Solar Cells

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Nanocrystalline titanium dioxide ($TiO_2$) materials have been widely used as an electron collector in DSSC. This is required to have an extremely high porosity and surface area such that the dye can be sufficiently adsorbed and be electronically interconnected, resulting in the generation of a high photocurrent within cells. In particular, their geometrical structures and crystalline phase have been extensively investigated as important issues in improving its photovoltaic efficiency. In this study, we present a new strategy to fabricate a photoelectrode having a periodic structured $TiO_2$ film templated from 1D or 3D polystyrene (PS) microspheres array. Monodisperse PS spheres of various radiuses were used for colloidal array on FTO glasses and two types of photoelectrode structures with different $TiO_2$ materials were investigated respectively. One is the igloo-shaped electrode prepared by $TiO_2$ deposition by RF-sputtering onto 2D microsphere-templated substrates. At the interface between the film and substrate, there are voids formed by the decomposition of PS microspheres during the calcination step. These holes might be expected to play the predominant roles as scattering spherical voids to promote a light harvesting effect, a spacious structure for electrolytes with higher viscosity and effective paths for electron transfer. Additionally the nanocrystalline $TiO_2$ phase prepared by the RF-sputtering method was previously reported to improve the electron drift mobility within $TiO_2$ electrodes. This yields solar cells with a cell efficiency of 2.45% or more at AM 1.5 illumination, which is a very remarkable result, considering its $TiO_2$ electrode thickness ($<2\ \mu m$). This study can be expanded to obtain higher cell efficiency by higher dye loading through the increase of surface area or multi-layered stacking. The other is the inverse opal photonic crystal electrode prepared by titania particles infusion within 3D colloidal arrays. To obtain the enlargement of ordered area and high quality of crystallinity, the synthesis of titania particles coated with a organic thin layer were applied instead of sol-gel process using the $TiO_2$ precursors. They were dispersed so well in most solvents without aggregates and infused successfully within colloidal array structures. This ordered mesoporous structure provides the large surface area leading to the enough adsorption of dye molecules and have an light harvesting effect due to the photonic band gap properties (back-and-forth reflection effects within structures). A major advantage of this colloidal array template method is that the pore size and its distribution within $TiO_2$ photoelectrodes are determined by those of latex beads, which can be controlled easily. These materials may have promising potentials for future applications of membrane, sensor and so on as well as solar cells.

**Keywords:** Colloidal array, $TiO_2$, Photoelectrode, DSSC

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# Self-Organization and Phase Separation for Patterned Structures

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This talk demonstrates diverse patterned structures utilizing in-situ self-organization and phase separation of the materials into an ordered fashion. The patterned structures in this talk include electrospun nanofibers and electrosprayed microparticles embedding small particles. The positions of the small particles are in-situ controlled during the electrohydrodynamic process by the interaction with the polymer matrix. Another topic of the talk includes selective deposition of spin-coated materials on a corrugated surface that was prepared by buckling of polymer thin films. Solution are strong tendency to be positioned in the trench area of the surface, which facilitates the fabrication of micropatterns of diverse materials.

**Keywords:** Self-assembly, Phase separation