Study on Enhanced Photocurrent Properties at Dye/Gold Nanoparticles loaded TiO_2 Thin Films on Metallic Gratings

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Dye-sensitized solar cells have been attracted attention and widely studies due to the high energy-conversion efficiency and high potential of low manufacture costs. At the present time many studies on dye-sensitized solar cells (DSSCs) have been reported. Titanium dioxide (TiO_2) is one of the most efficient for dye-sensitized solar cells (DSSCs) due to its chemical stability, nontoxicity, good electrical properties and inexpensiveness.

It was previously reported that the short-circuit photocurrent in organic solar cells could be increased by using grating-coupled surface plasmon (SP) excitations, in which a blu-ray disc recordable (BD-R) is used as a grating substrate. The increased optical field by the SP excitation was used to enhance the photovoltaic properties of DSSCs because the active thin film can absorb more light, and it could generate more photocarriers, resulting in an increased photocurrent for the DSSCs. Grating-coupled SP excitations, which propagate adjacent to the grating metallic surface have been widely used in various applications. Therefore, the use of grating-structured Ag on DSSCs should enhance the photovoltaic properties of these systems.

The use of Au-TiO_2 on a metallic grating to enhance the photocurrent of photoanodes was also reported. Metal nanoparticles have been known as potential sensitizers in photovoltaics. Metal nanoparticles have very high absorption and scattering cross sections. Varying size and shape of metal nanoparticles could be modified throughout the visible region to the near infrared. Metal particles could enhance photovoltaic performance at least three different ways. In the first case, the local near field enhancement related with surface plasmon excitation is used to increase charge carrier generation. A second case uses the high scattering property of metal nanoparticles at the surface plasmon resonance wavelengths to re-direct light into a solar cell substrate. The third case is to use metal nanoparticles as the light harvesting part inducing charge separation in a photovoltaic cell.

In Chapter 2, TiO_2 and Au-loaded TiO_2 nanoparticles were synthesized by the modified sol-gel technique and coupling the modified sol-gel with impregnation technique respectively. The preparation of TiO_2 by the modified sol-gel method using cellophane membrane was performed to decrease the diffusion rates of reactants in hydrolysis and condensation steps. This synthesis technique had many advantages such as excellent reproducibility, excellent ability to acquire TiO_2 in nano-sized scale and excellent fabrication for high purity products. The obtained nanoparticles were used to enhance DSSCs performance. Dye/Au-loaded TiO_2 films were fabricated on an Au grating surface to couple with surface plasmon resonance (SPR) to further enhance the photocurrent in DSSCs.

In Chapter 3, the fabrication of a grating structure consisting of a solid-state electrolyte layer on a dye-TiO_2 film formed by the nanoimprint technique using a polydimethylsiloxane (PDMS) stamp was stud-

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ied. The application of this grating in solid-state DSSCs is also described. The PDMS grating pattern was imprinted from a BD-R. A silver electrode was deposited on the patterned solid-state electrolyte layers. SPR excitation was observed in the fabricated solar cells by irradiation with white light at the imprinted grating surface. The photoelectric conversion properties were measured to study the effect of the two types of SPR excitations, i.e., the propagating surface plasmon on the Ag grating surface and the localized surface plasmon from the Au nanoparticles on TiO_2