Study on Localized Surface Plasmon and Grating-coupled Surface Plasmon Enhanced Photoelectrocatalytic Electrode and Organic Photovoltaics

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This study demonstrated the use of localized surface plasmon (LSPR) and grating-coupled surface plasmon resonance (GCSPR) to enhance the photocatalytic activity of a thin film photocatalyst, particularly TiO_2 (P25), and the performance of thin film organic photovoltaic. We prepared plasmonic gold nanoparticle (AuNP) – TiO_2 nanocomposite and deposited on transparent-conductive electrode (indium-tin-oxide (ITO) coated glass) to obtain AuNP – TiO2 nanocomposite photoelectrocatalytic (PEC) electrode with the thickness of ~460 nm. The photocurrent that originates from the water-splitting reaction catalyzed by LSPR of the gold nanoparticles affected the generation of photocurrent by TiO_2 upon illumination with visible light was systematic measured. Moreover, we not only show the effect of LSPR in enhancement of the photocurrent of TiO_2 under visible illumination but also introduced a new method to enhance the photocurrent of TiO_2 by a multiple plasmonic effect, i.e., the cooperation of LSPR of plasmonic gold nanoparticles and the GCSPR of a gold grating. Moreover, we emphasize on the improvement of the photocurrent and the photo-electricity conversion efficiency of thin film P3HT:PCBM solar cells by GCSPR. The Blu-ray disc recordable (BD-R) and Blu-ray disc (BD) grating pattern (Λ = 330 nm) were created on the active layer of the solar cell using pressure-less nanoimprinting technique, following by thermal evaporation of aluminum to obtain the BD-R and BD grating back electrode. The surface plasmon (SP) reflectivity curves of the fabricated solar cell reveal the decrease of the reflection spectra of the solar cells with BD-R and BD grating compare with the flat device. This can be implied to the increase of the trapped light in the device due to the BD and BD-R grating structures that can be assigned to two regions included the increase of the light trapping at 400 – 650 nm attributed to the light scattering effect. The irradiation photon can be coupled into GCSPR that propagates along the surface of the diffraction grating which can be observed as the occurrence of the dip peaks at the wavelength longer than 650 nm. The I-V characterization results show the improvement of photocurrent about 10% and 5.6% for the BD-R and BD solar cell, respectively. Moreover, the enhancement of the photoconversion efficiency of 19.3% can be obtained from BD-R solar cell while those of solar cell with BD grating can be improve the photoconversion efficiency of 3.2% compared to flat solar cell.

In the thesis, there are four chapters. The first is an introduction which gives about background and some involved knowledge about the study. For the second chapter, this chapter will talk about the use of LSPR and GCSPR for enhancement of the photocurrent property of TiO_2 (P25). There are some details inside this chapter included, introduction,

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experimental section, results and discussion, and conclusion. For the third chapter, this chapter will talk about how to use the grating-coupled surface plasmon resonance to enhance the performance of thin film organic solar cell. Inside this chapter, there are introduction, experimental section, results and discussion, and conclusion. For the fourth chapter, the last one, the conclusion and the suggestion for the future is presented.