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Development of Visible-light Responsive TiO_2 Thin Film Photocatalysts by Magnetron Sputtering Method and Their Applications as Green Chemistry Materials

Masaya MATSUOKA†

Department of Applied Chemistry, Osaka Prefecture University
(matsumac@chem.osakafu-u.ac.jp†)

Water splitting reaction using photocatalysts is of great interest in the utilization of solar energy [1]. In the present work, visible light-responsive TiO_2 thin films (Vis-TiO_2) were prepared by a radio frequency magnetron sputtering (RF-MS) deposition method and applied for the separate evolution of H_2 and O_2 from water as well as the photofuel cell. Special attentions will be focused on the effect of HF treatment of Vis-TiO_2 thin films on their photocatalytic activities.

Vis-TiO_2 thin films were prepared by an RF-MS method using a calcined TiO_2 plate and Ar as the sputtering gas. The Vis-TiO_2 thin films were then deposited on the Ti foil substrate with the substrate temperature at 873 K (Vis-TiO_2/Ti). Vis-TiO_2/Ti thin films were immersed in a 0.045 vol% HF solution at room temperature. The effect of HF treatments on the activity of Vis-TiO_2/Ti thin films for the photocatalytic water splitting reaction have been investigated. Vis-TiO_2/Ti thin films treated with HF solution (HF-Vis-TiO_2/Ti) exhibited remarkable enhancement in the photocatalytic activity for H_2 evolution from a methanol aqueous solution as well as in the photoelectrochemical performance under visible light irradiation as compared with the untreated Vis-TiO_2/Ti thin films. Moreover, Pt-loaded HF-Vis-TiO_2/Ti thin films act as efficient and stable photocatalysts for the separate evolution of H_2 and O_2 from water under visible light irradiation in the presence of chemical bias. Thus, HF treatment was found to be an effective way to improve the photocatalytic activity of Vis-TiO_2/Ti thin films.

Furthermore, unique separate type photofuel cell was fabricated using a Vis-TiO_2 thin film as an electrode, which can generate electrical power under solar light irradiation by using various kinds of biomass derivatives as fuel. It was found that the introduction of an iodine (I^- / I_3^-) redox solution at the cathode side enables the development of a highly efficient photofuel cell which can utilize a cost-efficient carbon electrode as an alternative to the Pt cathode.

[1] M. Matsuoka, M. Kitano, M. Takeuchi, M. Anpo and J.M. Thomas, Top. Catal., 35, 305 (2005).

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PT-2

Toward Industrial Applications of Graphene Electrodes

홍병희†

성균관대학교
(byunghee@skku.edu†)

There have been many efforts to utilize the outstanding properties of graphene for macroscopic applications such as transparent conducting films useful for flexible/stretchable electronics. However, the lack of efficient synthesis, transfer, and doping methods limited the scale and the quality needed for the practical production of graphene films. In this presentation, we introduce ultra-large scale (~30 inch) synthesis, roll-to-roll transfer, and chemical doping of graphene films showing excellent electrical and physical properties suitable for practical applications. Considering the outstanding scalability/processibility of roll-to-roll and CVD methods and the extraordinary flexibility/conductivity of graphene films, we expect the commercial production and application electrodes replacing the use of ITO can be realized in near future.