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The Character of Photo-electrochemistry of Palladium Implanted TiO_2 Nano-crystalline Electrode

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Abstract: A new electrode was prepared by using Pd implanted into nano-crystalline TiO_2 and the character of photo-electrochemistry of implanted electrodes was investigated. The energy band structure of nano-crystalline TiO_2 has not changed after implantation with Pd. The photo-current (i_{ph}) of palladium implanted TiO_2 nano-crystalline electrode is larger than that of pure TiO_2 nano-crystalline electrode.

Keywords: Ion implantation, photo-electrochemistry, titanium dioxide, palladium, nano-crystalline

Many methods have been adopted to improve the character of photo-electrochemistry of TiO_2[1,2]. Ion implantation is a technique with unique advantage to modify other electrodes and has been used in many electrochemical research fields[3]. In this paper we chose palladium ion implantation to modify nano-crystallineTiO_2 and investigated the effect of implanted Pd.

Experimental

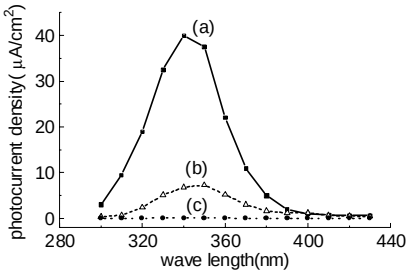
The nano-crystalline TiO_2 was prepared with hydrothermal method which was reported elsewhere[4]. The pH of reaction media was controlled at pH 1.8. The suspension of $TiO_2$was covered on the ITO glass, sintered in the oven at 450℃ for 30 min and cooled to room temperature at once. A layer of porous TiO_2 film formed on the conducing glass, designated as TiO_2/ITO. The implantation of Pd (99.9%) was carried out by using a metal vapor vacuum arc (MEVVA) source ion implanter. The implanted electrodes were designated as Pd/TiO_2/ITO. The extracting voltage and beam current of Pd ion beam were about 45 KeV and 1mA, respectively. The implanted doses of Pd are 5×10^{15} ions/cm^2 and 1×10^{16} ions/cm^2. The photo-electrochemical measurements were carried out by using a standard three-electrode system equipped with quartz window, a saturated calomel reference electrode and a Pt plate counter electrode. 0.1 mol L^{-1} NH_4SCN solution (pH=7) was used as electrolyte. A Model 173 potentiostat was used for potentionstatic control and a Type 3036 X-Y Recorder was used for recording i_{ph}. The light source was a 200 W Xenon lamp. The area of light spot was 0.2 cm^2.

The TiO_2/ITO electrode was immersed into 0.1 mol.L^{-1} NH_4SCN. At stable open-current potential the wave length (λ) of monochromatic light was changed from 300 nm to 430 nm, i_{ph} corresponding to each λ was recorded. From 300 nm to 340 nm,

the i_{ph} increased rapidly and reached its maximum at the scope of wave length, from 340 nm to 350 nm. When the wave length became longer than 350 nm, the i_{ph} became decline (**Figure1**). The character of i_{ph}— λ curve was determined by the energy band structure of TiO_2.

Under the same conditions, the i_{ph}- λ curve of Pd/TiO_2/ITO (5×10^{15} ions/cm^2) or Pd/TiO_2/ITO (1×10^{16} ions/cm^2) electrode was recorded respectively. The outline of each i_{ph}— λ curve of Pd/TiO_2/ITO electrode is the same as that of TiO_2/ITO electrode. It indicated that the energy band structure of TiO_2 has not changed by implantation with Pd. In addition, the result revealed that i_{ph} of Pd/TiO_2/ITO (5×10^{15} ions/cm^2) or of Pd/TiO_2/ITO (1×10^{16} ions/cm^2) electrode is about 95 times or 18 times greater than that of TiO_2/ITO electrode (**Figure1**).

Figure1 The i_{ph}- λ curve of Pd implanted TiO_2 electrodes (a) 5×10^{15} ions/cm^2, (b) 1×10^{16} ions/cm^2 and (c) bare TiO_2 electrode



It is ascribed to forming Pd/TiO_2 interface. Because the work function of palladium is larger than that of TiO_2, at the interface of two materials, electron migrating from TiO_2 to palladium occurs until the two Fermi levels are aligned[1]. So a space charge layer forms at the interface of two materials which are connected electrically. The space charge layer favors the separation of photo-generated electron-hole pairs, so i_{ph} became larger. Comparing i_{ph} of Pd/TiO_2/ITO electrodes with different implantation doses, it was found that the i_{ph} did not increase with the increasing of implantation dose. The details will be investigated further.

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References

1. A.L.Linsebigler, G.Q.Lu, J.T.Yates.Jr., *Chem.Rev.*, **1995,** *95,* 735.
2. K.Hirano, K.Inoue, T.Yatsu, *J.Photochem.Photobiol.A: Chem.*, **1992,** *64,* 255.
3. G.K.Wolf, *Rad.Eff.*, **1982**, *65*, 107.
4. H.M.Cheng, J.M.Ma *et.al*, *Chem.Mater.*, **1995,** *7,* 663.

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