Re-annealing effect on the structure and photo-electrochemical character of the annealed hematite nanorods fabricated by electrochemical etching

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Renewable energy correlated to hydrogen utilization has been considered as one of potential solutions to solve nowadays urgent issues that humankind encountered in energy crisis and global warming. According to Fujishima and Honda in 1972, photoelectrochemical (PEC) water splitting is a promising method to convert the solar energy into hydrogen that could be further utilized. Among the extensively investigated semiconducting materials such as TiO_2, ZnO, Cu_2O and α-Fe_2O_3, hematite (α-Fe_2O_3) was of concern to be a good candidate in photoelectrochemical water splitting because of its ideal band-gap (~2.2 eV) for visible light absorption and good stability in the electrolyte. A variety of methods were used to prepare hematite for photocatalyst, including spray pyrolysis, chemical vapor deposition, sol-gel method, sputtering and electrochemical etching. Electrochemical etching was chosen in the work on consideration of low cost and feasible production in large-scale.

Figure 1 depicted the photo anode consisting of hematite nanorods photo-catalyst coated on F-doped SnO_2 (FTO) glass substrate. In Fig. 1, α-F_2O_3 doped carbon thin layer was used as a buffer layer between hematite nanorods and FTO. These photo anodes were annealed at 550℃ for 1 h and re-annealed at 600, 650, 700 and 750℃ for 10 min. to investigate the temperature effect of re-annealing on the crystalline structure, optical and photoelectrochemical properties of hematite. Resulting from X-ray photoelectron spectra (XPS), figure 2 revealed that tin (Sn) could be detected on the surface of the specimen re-annealed at 750 ℃. The photocurrent could be determined under de-aerated condition by means of a standard three-electrode system where hematite photo anode used as the working electrode, a foil of Pt foil as the counter electrode and a saturated calomel electrode (SCE) as the reference electrodes, respectively, The solar spectrum of the system was simulated by using a Xe-lamp equipped with AM 1.5 filters. The photo current density (Fig. 3) demonstrated at 0.4 mA/cm^2 bias of 0.6 V vs. SCE for the specimen annealed at 550℃ for 1 h and re-annealed at 750℃ for 10 min.

In summary, the photo anode having been re-annealed at 750℃ for 10 min indicated a better photoelectrochemical property than that simply annealed at 550℃ for 1 h. The activation of the electrode in this specifically re-annealed case may be attributed to Sn-deposition on the anode surface of hematite through its diffusion from the FTO substrate in the re-annealing duration. Phenomena of the optimal photoelectrochemical property were also discussed.

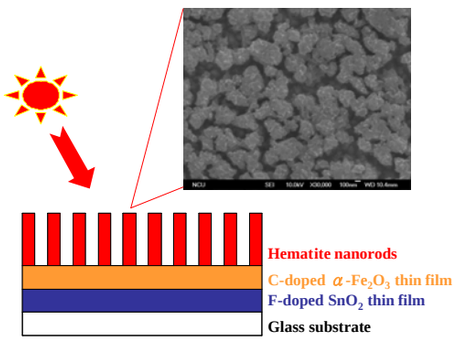

Figure 1. Schematic diagram of the hematite photo anode.

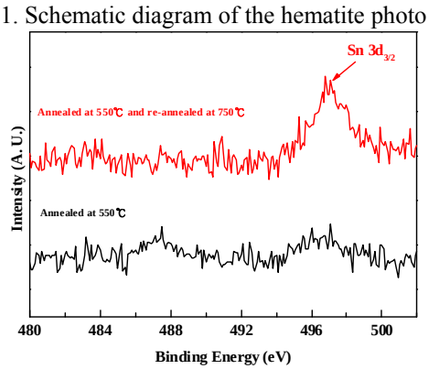

Figure 2. Sn $3d_{3/2}$ XPS spectra of hematite annealed at 550 with and without re-annealed at 750 ℃ for 10 min.

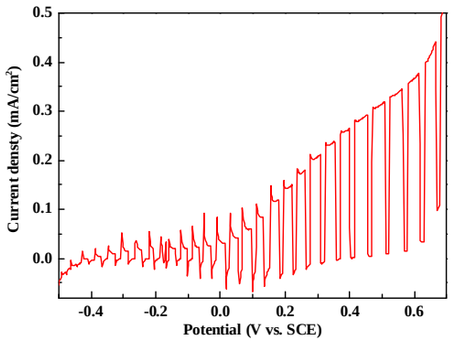

Figure 3. The photocurrent density of hematite annealed at 550℃ for 1 h and re-annealed at 750℃ for 10 min.

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