

Electroplating Tin Oxide on Stainless Steel in Nitric Acid Solution

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ABSTRACT- A novel procedure to coat tin oxide by electroplating was conducted in this study. The advantages of this procedure are inexpensive, safe and controllable. In recent years, deposition of metal oxides by electroplating, including zinc oxide, copper oxide and silver oxide, have been an active research area. But the process is hard to control for tin oxide, because Sn metal and SnO can be formed at the same time. A new procedure to coat tin oxide without tin metal by electroplating has been developed and their growth characteristics are summarized.

EXPERIMENT- Plating solution was composed of 20 mM tin chloride (SnCl_2) and 75 mM nitric acid with adequate stirring for 1 h. In order to prevent stannous ion from being oxidized into stannic ion, the whole process was deoxygenated with flowing nitrogen gas.

Electroplating was performed in a three-electrode cell. Stainless steel foil and Sn metal plate were used as the working electrode and the counter electrode, respectively. The range of applied voltage was -200 mV to -400 mV vs. Ag/AgCl(0.222V/NHE), and the current range is between 0.5 and 20 mA. The tin oxide film was analyzed by SEM and X-ray diffraction.

RESULTS AND DISCUSSIONS- The cyclic voltammogram of SnCl_2 solution is shown in figure 1. NO_3^- was reduced to NO_2^- and OH^- when the potential was lower than -300 mV (peak I). The OH^- reacted with Sn^{2+} to form $\text{Sn}(\text{OH})_2$, then $\text{Sn}(\text{OH})_2$ would become SnO. Hydrogen formed when potential was lower than -700 mV. Sn metal was also reduced when OH^- was formed, and Sn was oxidized to Sn^{2+} ion at 150 mV (peak II) consequently. Unavoidably, Sn metal and SnO electroplated on substrate at the same time. But we can get a superior SnO thin film by controlling electroplating parameters with chronoamperometric or chronovoltametric techniques.

XRD pattern was showed in figure 2. There were several obvious peaks and a broad one around 30 degrees besides the peaks of substrate. XRD pattern shows the film is tin oxide as evidenced by a stronger peak at 31.6 degree. Observation of film morphology was shown in figure 3. At the initial stage, the tin oxide nucleated at several places on the substrate and started to grow. The film is composed of discontinuous blocks, like figure 3(a). And then these blocks kept growing and formed a continuous film, like figure 3(b). The particle size is about 100 nm, as observed from figure 3.

From the above results, a novel procedure to coat tin oxide without tin metal incorporation has been developed. The high-quality tin oxide film can be applied as sensor and electrode very well, and these issues are on-going currently.

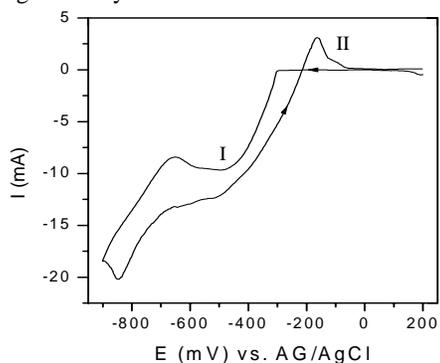


Fig.1 Cyclic voltammogram of SnCl_2 solution. (I). Formation of OH^- . (II). Sn metal reduced to Sn^{2+} .

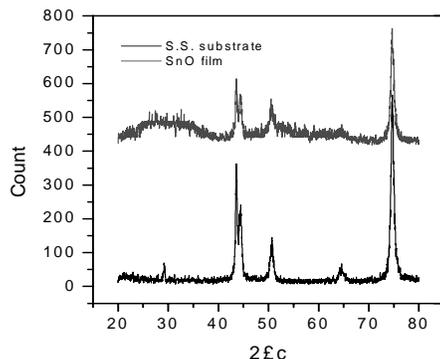


Fig2. XRD pattern of substrate and tin oxide film.

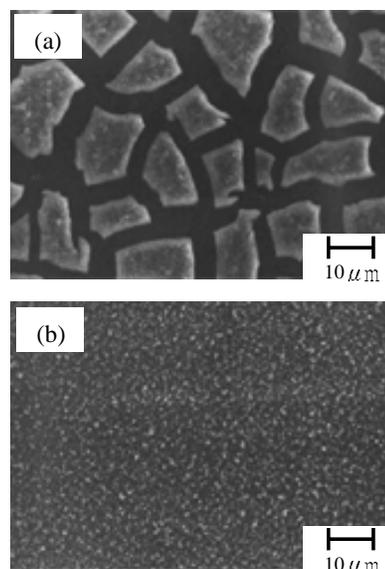


Fig3. SEM micrographs of tin oxide film. Deposited at 300 mV for (a) 15 min. and (b). for 60 min.