Photoelectrochemistry and Electrochromism in Electrodeposited WO_3-TiO_2 Composites

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The photoelectrochemistry of nanostructured semiconductor films is of considerable interest due to their particle-size dependent behavior. TiO_2 and WO_3 are among the most studied oxide semiconductor materials for their applications in solar cells and photocatalytic reactors. Additionally WO_3 is the active component in electrochromic devices.

The aim of this paper is to present a comparative study of WO_3-TiO_2 composite films in terms of their photoelectrochemical, photocatalytic, and electrochromic properties. Films consisting of both components were either electrodeposited, or studied with one component as a film matrix and the other occluded as nanoparticles.

We have designed and optimized a potential-step sequence for the electrodeposition of these WO_3-TiO_2 composite films on transparent conducting oxide (TCO) slides. The resultant films have superior photoelectrochemical and photocatalytic properties relative to their parent end-members. For electrochromic films, we used a similar potential-step strategy but with a different sequence and duration. Films for photoelectrochemical applications require a thermal anneal at 350 °C for 30 min, but not for films prepared to perform electrochromically.

Electrodeposition was carried out in an electrolyte solution containing the peroxo precursor species for both components[1-4]. It consists in the application of a potential-step sequence with each step favoring the formation of one parent member into the composite. Figure 1 contains a representative potential-time program (a) and the resulting current (b) that leads to film formation.

A series of WO_3-TiO_2 films with different relative composition of its members were prepared. They show photocurrent-potential profiles with efficiencies at least double those of the parent members. The incident photon-to-current-conversion efficiency (IPCE %) as a function of the wavelength and at an applied potential of 1.2 V vs. Ag/AgCl reference electrode is presented in Fig. 2 for a representative WO_3-TiO_2 film and for the two individual components. Interestingly, WO_3-TiO_2 films follow the IPCE pattern of its WO_3 parent for wavelengths higher than 360 nm, but with a significantly higher performance at lower wavelengths.

Superior photocurrent performance can be also secured by immobilizing TiO_2 and WO_3 nanoparticles in a WO_3 electrodeposited film matrix. These different film structures will be compared and contrasted for different applications.

References

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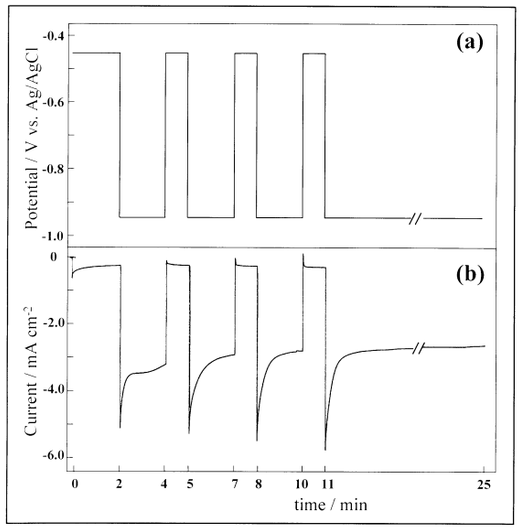

Fig. 1 – Potential/time sequence (a) and the resulting electrodeposition current (b) for formation of a WO_3-TiO_2 film.

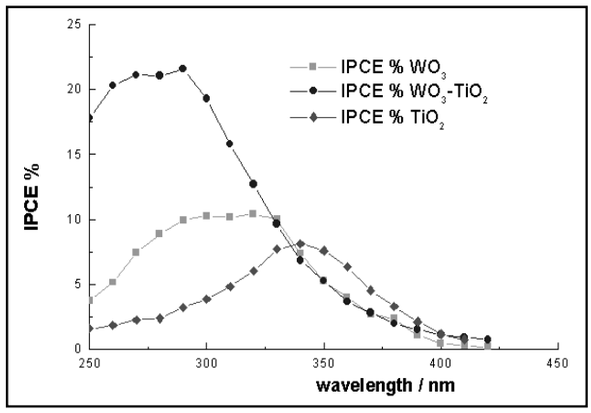

Fig. 2 – IPCE % photocurrent efficiency for an electrodeposited WO_3-TiO_2 film in 0.1 M Na_2SO_4.