Nanostructured tungsten trioxide thin films by aqueous chemical growth for applications in gas sensing and electrochromism

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Abstract

Aqueous Chemical Growth (ACG) [1-3] is a low cost, low temperature and environmentally benign wet-chemistry technique that has been used to synthesize thin films and coatings of multi-functional Semiconductor Metal Oxides (SMO) that often find applications in gas sensing, smart windows, batteries, supercapacitors, etc.

We report here the use of the ACG technique to produce on bare Corning glass and F-doped Tin Oxide-on-glass (FTO) thin films of WO_3, a SMO, which finds applications in gas sensing and electrochromic devices. SEM showed that nanoplatelet-containing structures were generally produced on the Corning glass substrates while urchin-like microspheres were produced on the FTO substrates. TEM, HRTEM, were used confirm the morphology of the structures observed in SEM while XRD alongside Raman spectroscopy were used to show that WO_3 in the thin films existed in the monoclinic, cubic and hexagonal phases.

While the WO_3 thin films prepared on Corning glass substrates were evaluated for their gas sensing behaviour with respect to hydrogen, CO, and CO_2 (flammable and poisonous gases common in mining and industrial environments), those that were prepared on FTO where evaluated for their electrochromic behaviour using Cyclic Voltammetry and UV-Vis-NIR spectrophotometry.

Results obtained on gas sensing showed that WO_3 thin films on Corning glass are suitable for hydrogen sensing in the 200-350°C temperature window (Fig.1). Doping these thin films with graphene resulted in reduction of sensing temperatures to 100°C. Gas sensing of CO and CO_2 was also observed to take place for the undoped WO_3 thin films at temperatures of 200°C and above.

For electrochromism (Fig. 2), the WO_3 thin films on FTO demonstrated fairly fast optical switching rates from blue to colourless, of less than 30 seconds upon H^+ intercalation in 0.1 M H_2SO_4 electrolytic medium. This makes them potentially applicable for use as electrochromic materials in electronic displays, smart windows and other devices were optical switching is needed.

References

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Figures

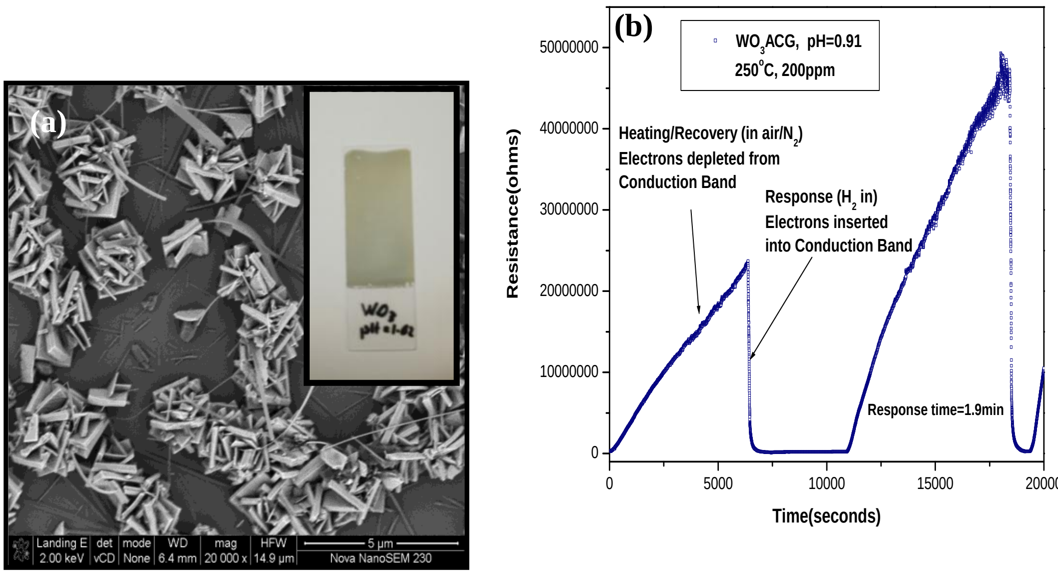

Fig.1. (a) SEM micrograph of WO_3 nanoplatelet-containing desert-rose like structures; (b) Hydrogen sensing of WO_3 thin film by Aqueous Chemical Growth at 250°C. Inset in Fig.1a shows WO_3 thin film on Corning glass.

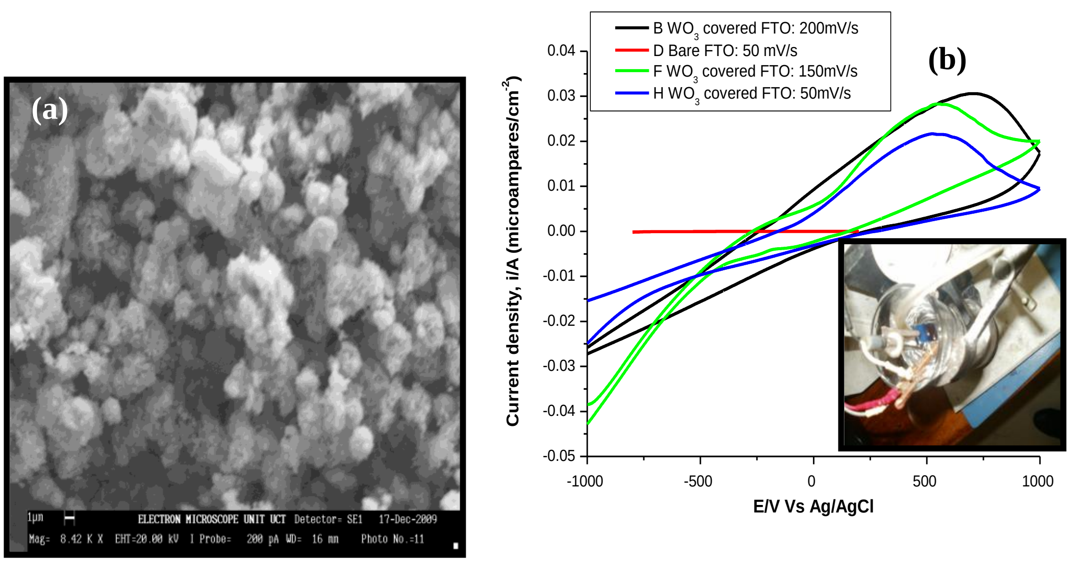

Fig.2. (a) SEM micrograph of WO_3 urchin-like microspheres produced by ACG; (b) Cyclic voltamogramme of H^+ intercalation in WO_3 thin films on FTO carried out in 0.1M H_2SO_4 medium. Inset in Fig. 2b shows electrochromic effect in WO_3 thin film on FTO.