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ELECTROCHEMICAL DEPOSITION AND CHARACTERIZATION OF TUNGSTEN OXIDE AS ELECTROCHROMIC FILMS

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ABSTRACT

Tungsten oxide (WO_3) has been extensively studied material for preparation of electrochromic film for smart windows applications. This work reports the preparation of WO_3 films by electrodeposition technique. The effects of electrodeposition parameters such as deposition solution and deposition conditions on the structural, morphological and electrochromic properties of electrodeposited WO_3 films were investigated. The deposited WO_3 films were characterized using FESEM for surface morphology, EDAX for elemental analysis, XRD for structural properties, Cyclic Voltammetry for electrochromic performance and UV-Vis Spectroscopy for optical properties. The stability of bath solution containing tungsten ions from two different precursors (W salt and W powder) played an important factor in the formation of WO_3 films on ITO-glass substrate. It was found that smooth, well adhered and transparent WO_3 films with good electrochromic performances (switching colouration and cycling stability during intercalation and deintercalation of H^+ ions) can be prepared from 0.05M tungstate ions (using W powder) + 10mL H_2O_2 in the presence of 30 mL 2-propanol by applying constant potential of –0.45V vs Ag/AgCl for 300s at 40°C. Post-treatment by annealing has significantly changed the surface morphology and structural property of WO_3 films from amorphous to crystalline after annealed at T > 300°C. The crystalline WO_3 films have poor electrochromic performance than the amorphous films due to the entrapment of H^+ ions into the crystalline structure of WO_3 films. The coloured WO_3 film has reflected about 70% the transmission of near-IR light (ie: solar heat). The prepared WO_3 film is a great potential to be used as an electrochromic film in vehicles and building industries.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Over the last two decades, there has been progressive interest in the fabrication of thin solid film materials for many advanced applications. Thin films of metal oxides such as Zinc Oxide (ZnO), Nickel Oxide (NiO), Lead Oxide (PbO_2) and Tungsten Oxide (WO_3) have been the materials of quickly growing attention due to their interesting physicochemical and optical properties. Properties of WO_3 films such as electrochromism, electrical and optical have been exploited for many technological applications such as for the development of sensors (Sadex, Woldarski, & Shin, 2008), smart windows (Lampert, 1984), electrochromic devices (Badilescu & Ashrit, 2003), catalytic material (Xiang, et al., 1995) and electrosynthesis of organic compounds (Guglielmi, 1972).

WO_3 films can be deposited onto substrates with the use of various methods, such as vacuum techniques sputtering (Nanba et al., 1994), thermal evaporation (Bohnke, Bohnke, Robert, & Carquille, 1982) and chemical vapor deposition (Bange, 1999); and also chemical methods such as spin coating, spray pyrolysis, sol-gel deposition and electrochemical deposition (Lee, 1997; Leftheriotis & Yianoulis, 2008; Yu, Jia, Du, & Zhang, 2000). Electrochemical deposition is a versatile technique for the synthesis of materials with a variety of morphologies and structures. The control of current (i.e.: galvanostatic) or voltage (i.e.: potentiostatic) permits to vary the amount or thickness of deposited materials using electrochemical deposition technique.

The fabrication of WO_3 films with nanostructure and highly porous opens up the way to tailor the physical (e.g.: effective surface area, thermal stability, energy gap) and chemical (e.g.: surface reactivity, stoichiometry, chemical stability) properties in view of electrochromic devices development. The electrochemical and optical properties of WO_3 films are strongly related to their morphology, porosity and the size of the WO_3 particles (Yang, Li, Blackford, &Luca, 2006). The electrochromic activities of WO_3 film can be improved by reducing its particle size