Сојуз на хемичарите и технолозите на Македонија

Society of Chemists and Technologists of Macedonia

XXIII Congress

with international participation

BOOK OF ABSTRACTS

8-11 October 2014
Ohrid, R. Macedonia
Metropol Lake Resort

MST 008

ELECTROCHROMIC VANADIUM OXIDE THIN FILMS: FROM A LAYERED TO A TUNNEL STRUCTURE

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Vanadium oxide-based materials are very promising electrochromic materials since they have the potential to broaden the color palette displayed by inorganic electrochromics, and thus to extend the range of their functions.

The one-stage chemical deposition on FTO(define) substrates from a bath containing $NaVO_3$ and $(C_2H_5)_2SO_4$ at 85 °C yields xerogel thin films with the composition $Na_{0.33}V_2O_5{\cdot}H_2O$. The as-deposited films adopt a layered structure: double V_2O_5 slabs stacked along the *c*-axis of a monoclinic unit cell which are separated by Na^+ ions and water molecules. The complete dehydration at 375 ºC results in the transformation of the layered structure into a tunnel structure of monoclinic NaV_6O_{15} (or $Na_{0.33}V_2O_5$). This structure is built up from V_6O_{15} layers which are linked to each other by one oxygen atom per a unit cell giving rise to unidirectional tunnels. The Na^+ ions are localized within the tunnels where they can be easily intercalated. Three kinds of thin films with different thickness are studied: two films having a layered structure with compositions $Na_{0.33}V_2O_5{\cdot}H_2O$ (as-deposited) and $Na_{0.33}V_2O_5{\cdot}0.3H_2O$ (annealed at 250 °C) and thin films having a tunnel structure (annealed at 400 °C). The structure and surface morphology are examined by XRD, IR spectroscopy, SEM and AFM techniques. The electrochemical (cyclic voltammetry measurements) and optical properties (UV-Vis spectroscopy) are studied in $LiClO_4$ in propylene carbonate as an electrolyte. The cyclic voltammograms are characterized by three pairs of oxidation/reduction peaks related to the redox processes at different vanadium V(V) and V(IV) sites accompanied with the reversible lithium intercalation/deintercalation. All thin films exhibit two-step electrochromism from yellow to green, and then to blue with high values of the transmittance variance up to 68 % at 900 nm wavelength. This is a promising result for a potential application of the vanadium(V) oxide thin films in electrochromic devices.

Keywords: electrochromism, vanadium oxides, layered and tunnel structure

Acknowledgements: The financial support of the Bulgarian Academy of Sciences and Macedonian Academy of Sciences and Arts is gratefully acknowledged.