16th International workshop on Nanoscience and Nanotechnology - NANO 2014
November 6 - 8, 2014, Sofia, Bulgaria

ELECTROCHROMISM IN LAYERED VANADIUM – BASED THIN FILMS

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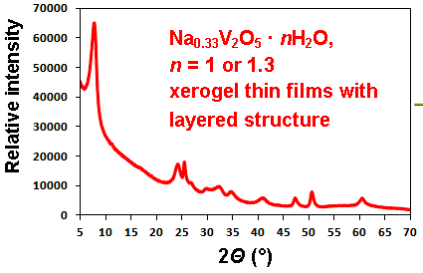
INTRODUCTION

Vanadium(V) oxide-based materials have the potential to broaden the color palette displayed by inorganic electrochromics, and thus to extend the range of their functions. The present contribution is focused on the electrochromic properties of thin films with compositions $Na_{0.33}V_2O_5{\cdot}nH_2O$ (n = 1 and 1.3) prepared by chemical bath deposition method on electroconductive F:SnO_2 coated glass substrates using $NaVO_3$ as precursor and diethyl sulphate (85 °C). Thin films with thickness between 50 and 300 nm are obtained for deposition times from 5 to 30 min.

CHARACTERIZATION of the THIN FILMS

1. Chemical and structural characterization

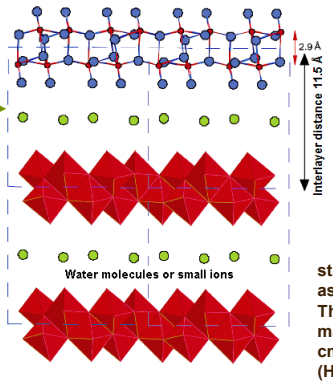
XRD patterns of as-deposited film



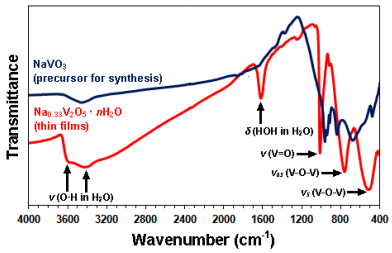
The XRD data show the formation of $Na_{0.33}V_2O_5{\cdot}nH_2O$ xerogels. The water content (n = 1 and 1.3) is determined by TG-DTA analysis.

The xerogels 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.

Layered structure



IR spectra of $Na_{0.33}V_2O_5{\cdot}nH_2O$ thin film and $NaVO_3$ precursor

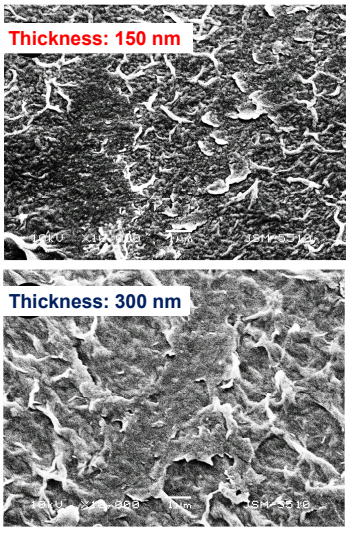


The IR spectra are dominated by the strong absorptions in the 1020 - 400 cm^{-1} region associated with the vibrations of V-O framework. The presence of water in the xerogel is clearly manifested by the bands at 3590 cm^{-1} and 3400 cm^{-1} (OH stretching vibrations) and at 1614 cm^{-1} (HOH bending vibration).

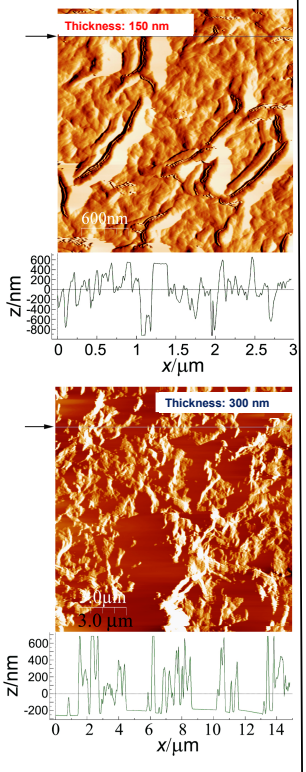
2. Morphological characterization

The FTO substrates are completely covered with the deposited material. As evidenced by SEM and AFM data the thin films morphology comprises both well separated nanoparticles with dimensions of 50-200 nm and long ribbon-like units with width of 100 - 300 nm and length up to several micrometers.

SEM images



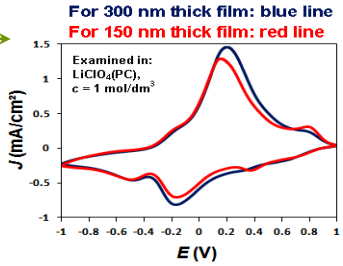
AFM images

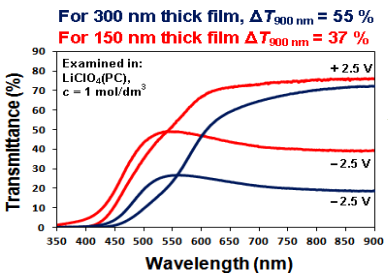


3. Electrochemical and optical characterization

Cyclic voltammetry measurements

The observed three redox pairs are related to reversible intercalation/ deintercalation of lithium ions accompanied with reversible reduction/oxidation processes between V(V) and V(IV) sites.



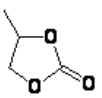


UV-Vis measurements

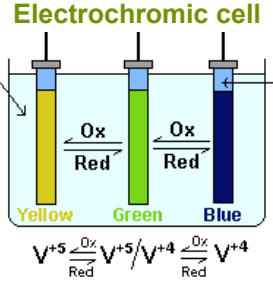
High values of transmittance variance at 900 nm are achieved: 37 % and 55 % for the films with 150 and 300 nm thicknesses, respectively.

Electrolyte:
$LiClO_4$ in PC
c = 1 mol/dm^3

PC – propylene carbonate



Electrochromic cell



FTO - coated glass substrate

- The thin films exhibit two-step electrochromism: from yellow to green and then to blue.

Two-step electrochromism

CONCLUSION

The sodium intercalated vanadium(V) oxides xerogel thin films with thickness of 150 and 300 nm are very promising materials for application in electrochromic devices due to the high values of transmittance variance (37 - 55 %) achieved

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