NANO 2013
21-23 November, 2013
Sofia, Bulgaria

INFLUENCE OF THERMAL TREATMENT ON THE ELECTROCHROMIC PROPERTIES OF SODIUM INTERCALATED VANADIUM(V) OXIDE XEROGEL THIN FILMS

Sasho Stojkovikj[1], Violeta Koleva[2], Metodija Najdoski[1]

[1]Institute of Chemistry, Faculty of Natural Sciences and Mathematics, Sts. Cyril and Methodius University, Skopje, Macedonia

[2]Institute of General and Inorganic Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria

INTRODUCTION

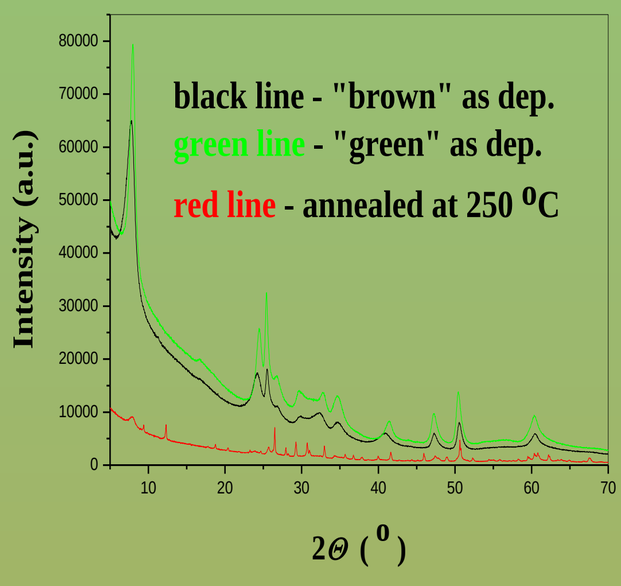
Vanadium(V) oxide xerogels are promising materials for application in different electrochromic devices. The present contribution is focused on the effect of thermal annealing on the electrochromic properties of as-deposited $Na_{0.33}V_2O_5{\cdot}H_2O$ thin films.

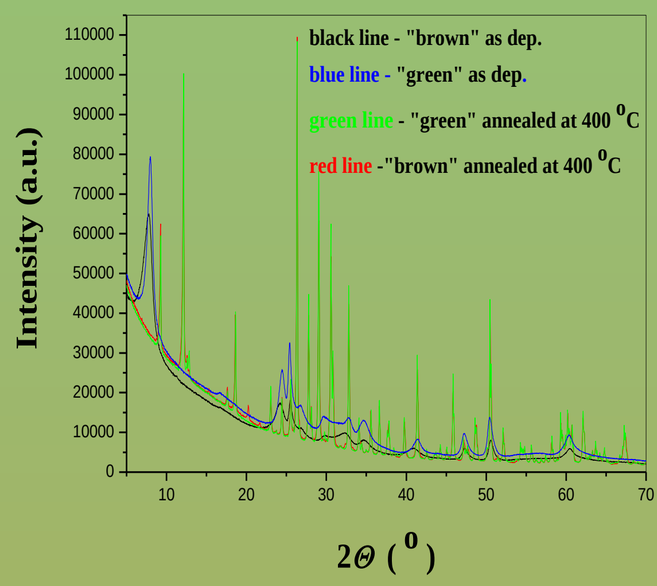
The deposition of homogenous $Na_{0.33}V_2O_5{\cdot}H_2O$ thin films on FTO coated glass substrates is performed at temperature of 85 °C from an aqueous solution containing $NaVO_3$ and $(C_2H_5)_2SO_4$. Then the "brown" samples turn "green" after ~ one week.

Both "brown" and "green" samples are annealed at 250 and 400 ºC and their electrochromic properties are studied.

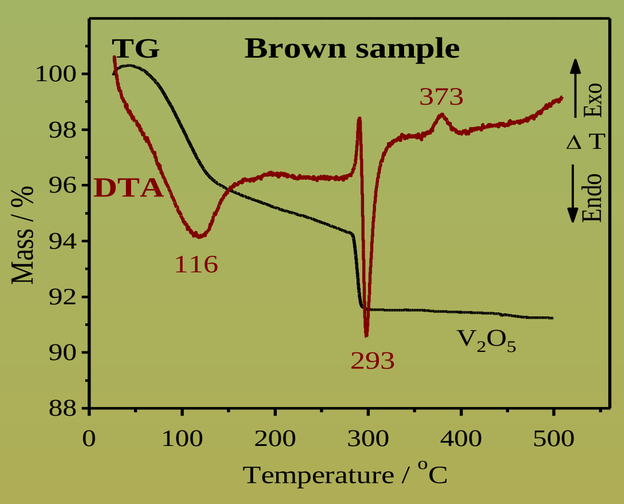
STRUCTURAL, CHEMICAL AND MORPHOLOGICAL ANALYSES

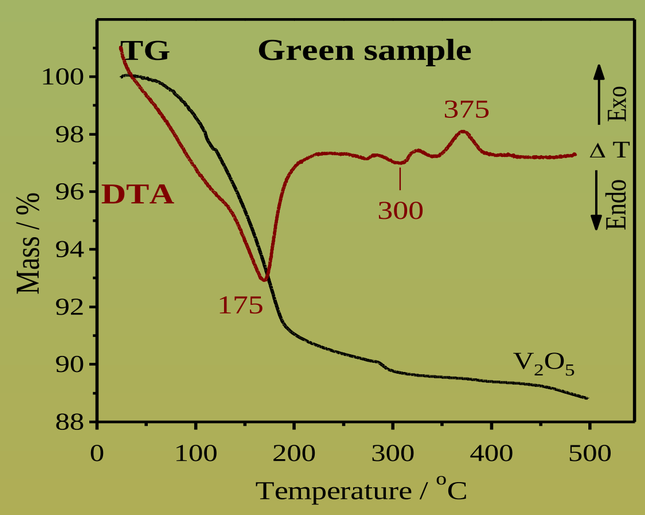
The structure and morphology of the annealed films are examined by XRD, IR spectroscopy and SEM. The water content in the as-prepared $Na_{0.33}V_2O_5{\cdot}nH_2O$ precipitates and the annealing process are followed by TG-DTA technique.





TG – DTA curves of "brown" and "green" samples.





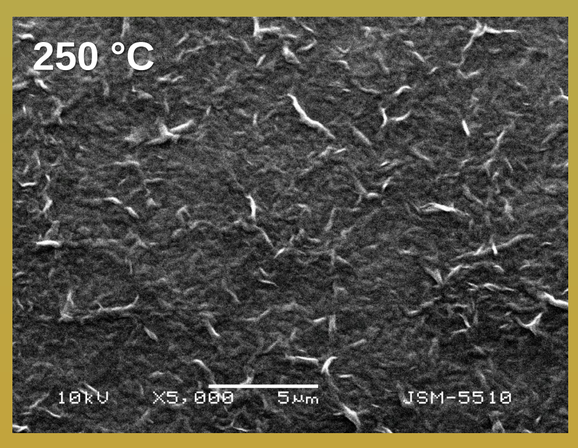
As-prepared films: $Na_{0.33}V_2O_5{\cdot}H_2O$ xerogel

Annealed at 250 °C: $Na_{0.33}V_2O_5{\cdot}0.3H_2O$ xerogel

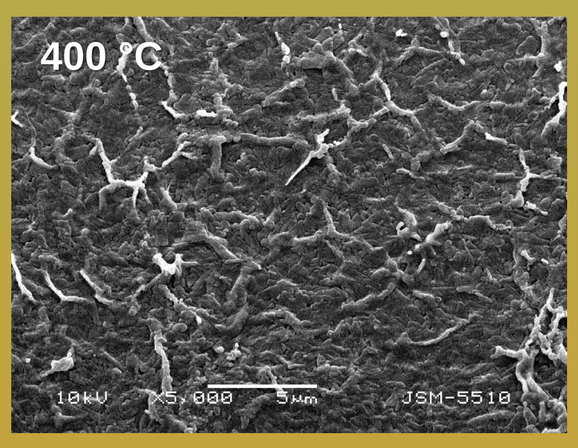
Annealed at 400 °C: NaV_6O_{15}.

SEM photomicrographs

$Na_{0.33}V_2O_5{\cdot}0.3H_2O$ xerogel



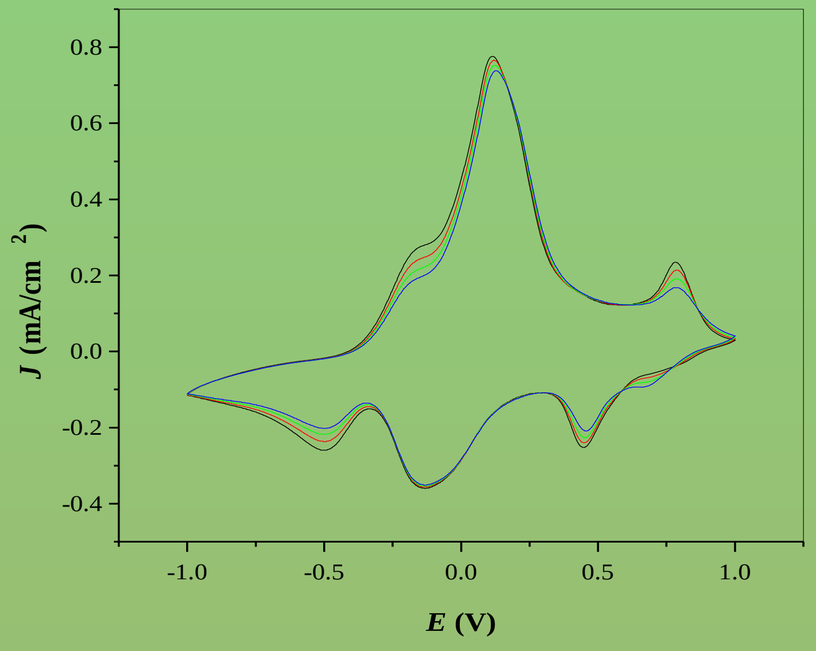
NaV_6O_{15}



SEM observations evidence that the film surface is well covered from ribbon-like units composed of nanoparticles.

ELECTROCHEMICAL CHARACTERIZATION

The electrochemical and optical properties are studied in 1M $LiClO_4$ in propylene carbonate (PC) as electrolyte.



CV curves of thin films annealed at 250 °C.

The observed three redox pairs are related to reversible intercalation/ deintercalation of Li^+ accompanied with reversible reduction/ oxidation processes between V(V) and V(IV) sites:

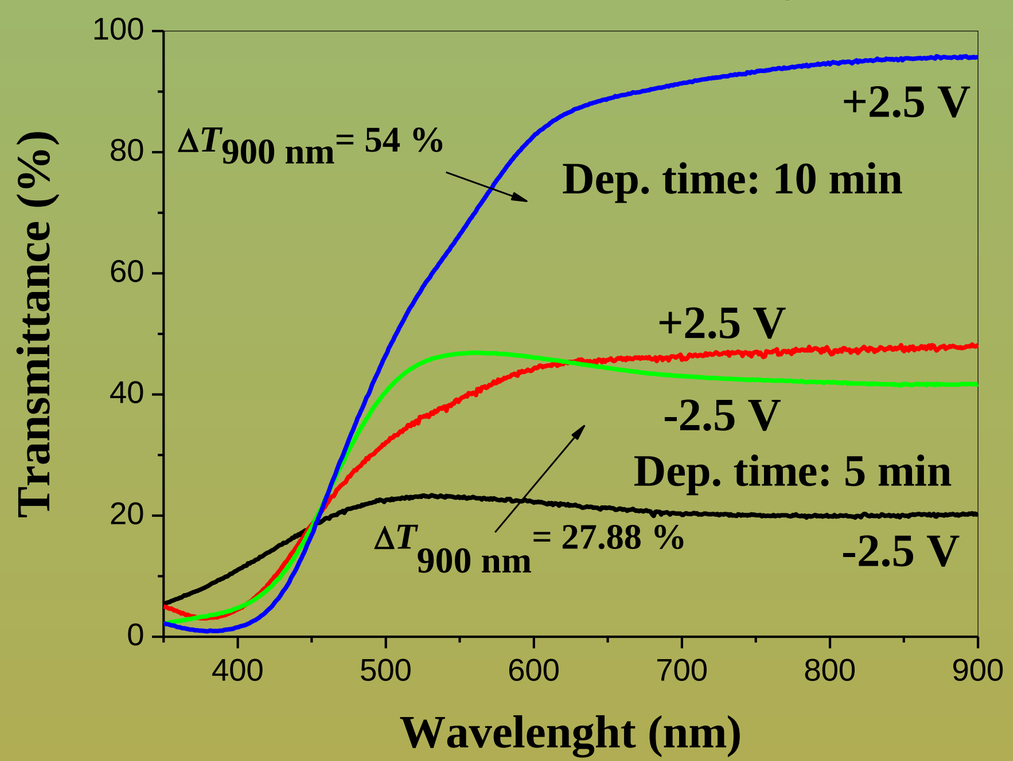
$$x\mathrm{Li^+(aq)} + \mathrm{Na_yV_z^{+4}V_{2-z}^{+5}O_5{\cdot}aH_2O(s)} + x\mathrm{e^-} \rightleftharpoons \mathrm{Li_xNa_yV_{z+x}^{+4}V_{2-z-x}^{+5}O_5{\cdot}aH_2O(s)}$$

"brown" "blue-gray"

UV-VIS SPECTRA OF ANNEALED THIN FILMS

The best electrochromic properties are achieved within the thin films annealed at 250 °C.

Annealed at 250 °C in electrochemically oxidized for



CONCLUSIONS

- The effect of thermal annealing at 250 and 400 ºC on the electrochromic properties of as-deposited $Na_{0.33}V_2O_5{\cdot}H_2O$ xerogel thin films is studied.
- The cyclic voltammetry shows that the Li^+ ions are reversibly intercalated/deintercalated within the prepared films.
- The prepared thin films exhibit two-step electrochromism: from orange to green and then from green to blue. The colour changes are related to the transitions between different oxidation vanadium states.
- The best electrochromic properties are obtained for the thin film prepared for 10 min deposition time and annealed at 250 °C. The transmittance variance ΔT at 900 nm for this film is 54 % which is an excellent value for application in different electrochromic devices.