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

Sasho Stojkovikj[1], Violeta Koleva[2] and 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

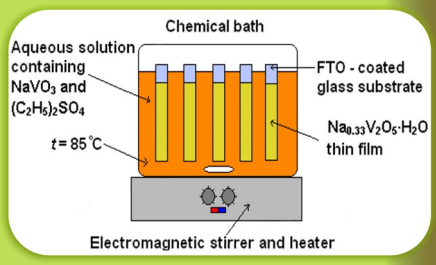
One of the most important properties of the materials used in various fields of high technology is electrochromism. A material is electrochromic if it has the capability to maintain reversible and persistent change in the optical properties (color change) when an electrical potential is applied to it. The reversible color change is induced by the change in the oxidation state of the metal ions which is associated with relevant insertion/extraction of ions from the electrolyte into/from the material. 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.

CHEMICAL BATH DEPOSITION

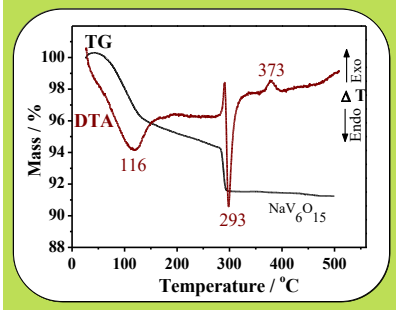
The electrochromic $Na_{0.33}V_2O_5{\cdot}H_2O$ thin films are deposited on electroconductive FTO glass substrates by a simple chemical bath method. The chemistry of the deposition process is based on the acidification of $NaVO_3$ solution as a result of the hydrolysis of diethyl sulfate above 65 °C:

$$(C_2H_5O)_2SO_2(aq) + 4H_2O(l) \rightarrow 2C_2H_5OH(aq) + 2H_3O^+(aq) + SO_4^{2-}(aq)$$

Brown colored $Na_{0.33}V_2O_5{\cdot}H_2O$ xerogel thin films are deposited on the conductive side of the substrate.



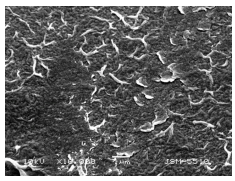
FILMS CHARACTERIZATION

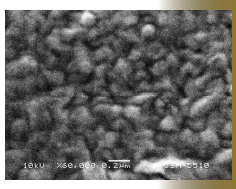


The complete dehydration at 375°C results in the transformation of $Na_{0.33}V_2O_5{\cdot}H_2O$ xerogel (layered structure consisting of double V_2O_5 slabs separated by Na^+ ions and water molecules) into NaV_6O_{15} (tunnel structure built up from V_6O_5 layers linked to each other by one oxygen atom per unit cell giving rise to undirectional tunnels

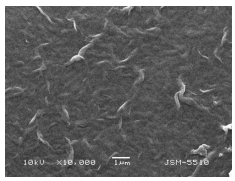
Films morphology

$Na_{0.33}V_2O_5{\cdot}H_2O$ — 150 nm thickness



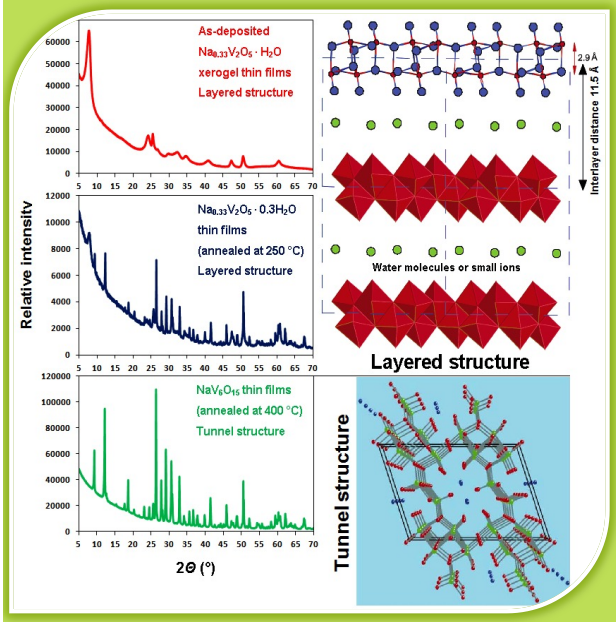


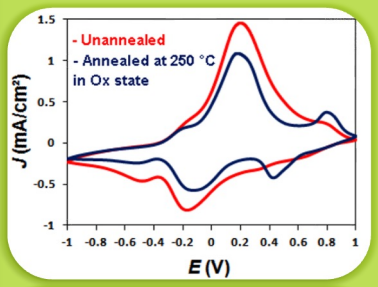
$Na_{0.33}V_2O_5{\cdot}0.3H_2O$



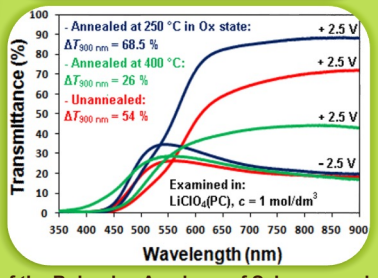
NaV_6O_{15}

- The FTO substrates are completely covered with the deposited material
- Xerogel films: randomly oriented ribbon-like units composed by nanograins (50 - 200 nm)
- NaV_6O_{15}: elongated particles with sizes of about 250 nm





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



- The three kinds of the films exhibit two-step electrochromism: from orange-brown to green and then to blue
- High values of transmittance variance at 900 nm: 54 - 68 %

CONCLUSION

Sodium intercalated vanadium(V) oxides xerogel thin films are very promising materials for electrochromic applications

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