Surface and material properties of nanostructured vanadium oxide films made by pulsed laser ablation

C.V. Ramana[1*], O.M. Hussain[1], R. Pinto[2] and C. Julien[3]
[1]Thin Film Laboratory, Department of Physics,
Sri Venkateswara University, Tirupati – 517 502, India
[2] Tata Institute of Fundamental Research, Colaba,
Mumbai – 400 005, India
[3]LMDH, UMR7603, Université Pierre et Marie Curie
4 place Jussieu, 75252 Paris cedex 05, France
[*]Present Address: Department of Physics, Montana State University, Bozeman, MT 59717, USA

Vanadium oxide (V_2O_5) films are useful for many technological applications most importantly in solid-state microbatteries. Recently extensive and successful efforts have been undertaken for fabrication of vanadium oxide thin films using pulsed laser deposition (PLD) at relatively low temperatures compared to other conventional deposition methods and demonstrated enhanced performance in electrochemical devices.

In the present work, pulsed laser ablated vanadium oxide thin films have been studied in detail to explore growth-property relationships and to refine the growth conditions for producing high quality vanadium oxide films for improving performance of devices. Studies are focused on the structural and morphological properties of V_2O_5 PLD films.

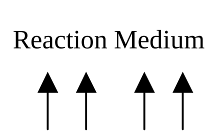
The investigations revealed that films are stoichiometric with well maintained O/V ratio. The AFM results indicated the finer microstructure of V_2O_5 thin films with nanostructured grains of nearly spherical shape with varying sizes forming an interconnected network. The average grain size is about 50 nm. The average and the root-mean-square value of the surface roughness derived from AFM are 12 nm and 14 nm, respectively. The height distribution of surface grains is Gaussian-like. XRD of PLD V_2O_5 films suggested the highly preferential growth along crystallographic c-axis. Local structure investigated by FTIR measurements also provide evidence for the structural quality with well-resolved rhombohedral symmetry. SEM results indicate that the films are uniform.

Table 1. Physical parameters for nanostructured V_2O_5 films.

Parameter	Value
Surface composition (V/O ratio)	2.5 ± 0.02
Average surface roughness	12 nm
Root mean square value of surface roughness	14 nm
Average grain size	50 nm
Optical band gap	2.35 eV
RT electrical conductivity	10^{-4} Scm^{-1}

The electronic structure studied near the fundamental transitions shows that the films exhibit a visible optical band gap of 2.35 eV and room temperature while an electrical conductivity of 10^{-4} S/cm was measured on nanostructured films. The temperature dependence of the electrical conductivity indicate that the films have a small polaron-like character. The physical parameters of nanostructured V_2O_5 films obtained in the present study are presented in Table 1.

Based on our investigations, we propose (Fig. 1) that, coupled with oriented structure all along, the high quality surface with enhanced packing and high surface area of nanostructured V_2O_5 films improves the interface formation for promoting device performance towards the reaction medium.



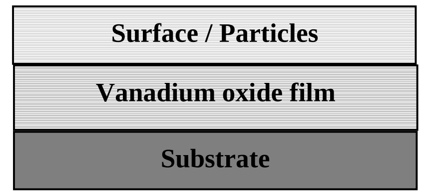


Fig. 1. Schematic diagram showing the nanostructured vanadium oxide film activating through the surface to the reaction medium.