Fundamentals and Technology of Multifunctional Materials and Devices

Room Royal Palm 1-3 - Session C3-1

Thin Films for Energy-related Applications

Moderators: Jim Partridge, RMIT University, Martin Allen, University of Canterbury

9:20am **C3-1-5 Solar Photovoltaic Energy Generation in Thermal Insulation Glazing**, ***David McKenzie,*** The University of Sydney, Australia **INVITED**

There is renewed interest in combining solar photovoltaic technologies with thermally insulating glazings. Modern cities have multi storey buildings with large areas of glazed facades that represent the majority of the building envelope. These facades have large energy exchanges with the environment that must be managed efficiently in order to avoid major energy wastage. The combination of PV technologies with thermal insulating glazings is a novel approach with potential to increase the harvesting of solar energy while minimising unwanted energy exchanges. New technologies for PV such as perovskite cells have shown good efficiency while allowing for some useful residual light transmission with an options for a choice of colour. There is a synergy with double glazed insulating units, first because of the local generation of energy while minimising losses, and second because the perovskite cells are moisture sensitive. In a synergistic design the thermal insulating glazing can act as a protective encapsulation of the cells. Recent advances and the current status of available technologies in this area will be discussed in this paper .

10:00am **C3-1-7 Effects of Annealing on Thermochromic Properties of W-doped Vanadium Dioxide Thin Films Deposited by Electron Beam Evaporation**, ***Shao-En Chen,*** National Cheng Kung University, Taiwan*; H Lu,* National Chin-Yi University of Technology, Taiwan*; S Brahma, J Huang,* National Cheng Kung University, Taiwan

Thermochromic vanadium dioxide (VO_2) undergoes a fully reversible semiconductor-metal transition (SMT) at a critical temperature T_t of ~68 °C with a dramatic change in electric and optical properties, which makes it an attractive candidate for use in smart windows. Switchable VO_2 and W-doped vanadium dioxide ($W_xV_{1-x}O_2$) thin films are grown successfully over quartz substrates via electron beam evaporation technique by using VO_2 / $W_xV_{1-x}O_2$ as targets at room temperature (RT) followed by a post annealing process at different temperatures. The films were characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, scanning electron microscopy (SEM) and optical transmittance measurement. The XRD analysis shows that the as-deposited films are amorphous, and that transform into (011)-preferred orientation of monoclinic VO_2 (VO_2(M)) after annealing at 500 °C under vacuum. Moreover, (011) peak of W-doped VO_2 films shifts to a lower diffraction angle as compared with un-doped VO_2 films which confirm the incorporation of W ions into the VO_2 lattice. Temperature dependent optical transmittance (T-T) measurement demonstrates the thermochromic properties, with a reduction in the phase transition temperature (T_t) as observed in W-doped VO_2 films, which is attributed to the variation of electron structure in VO_2 due to doping.

10:20am **C3-1-8 Fabrication and Characterization of Titanium Doped β-Ga_2O_3 Thin Films for Application in Oxygen Sensors**, ***Sandeep Manandhar,*** *E Rubio, R Chintalapalle,* The University of Texas at El Paso, USA

The electrical conductivity changes in metal oxides when exposed to atmosphere have attracted considerable interest in the field of gas sensing. Several candidate metal oxides (SnO_2, ZnO, TiO_2 and Ga_2O_3, WO_3) have high sensitivity to gases. Among these metal oxide, Gallium oxide (Ga_2O_3), the stable oxide of gallium, finds attractive applications in luminescent phosphors, high temperature sensors, antireflection coatings, and solar cells. Ga_2O_3 has been recognized as a deep ultraviolet transparent conducting oxide (UV–TCO), which makes the material a potential candidate for transparent electrode applications in UV optoelectronics. Ga_2O_3 thin film has proven to detect the presence of oxygen at high temperatures (>700 °C). However, recent trends and demand for reliable oxygen sensors imposed restrictions on the response time and sensitivity. In this work, we proposed and investigate to modify the properties of Ga_2O_3 by selectively doping with titanium (Ti). Ti doped β- Ga_2O_3 thin films with variable Ti content were deposited by co-sputtering of the Ga-oxide ceramic and Ti metal by varying the sputtering power to these targets. The effect of Ti on the crystal structure and electronic properties of β- Ga_2O_3 thin films is significant. The results will be presented and discussed in the context of utilizing these materials in oxygen sensor applications.

10:40am **C3-1-9 Bombardment of Tungsten Oxide Thin Layers by Low Energy of He and D Ions**, ***Hussein Hijazi,*** *Y Addab,* Aix-Marseille Université, France*; A Maan, J Duran, D Donovan,* University of Tennessee-Knoxville, USA*; C Pardanaud, M Cabié,* Aix-Marseille Université, France*; F Meyer, M Bannister,* Oak Ridge National Laboratory, USA*; R Pascal, C Martin,* Aix-Marseille Université, France

Tungsten is the plasma-facing material for next fusion reactors (e.g. ITER divertor) due to its high melting temperature, high thermal conductivity and low erosion yield. As a drawback, tungsten has a strong chemical affinity with oxygen and native oxide is naturally present on tungsten surfaces, which leads to the formation of tungsten oxide layers. In order to study the effect of oxidation on tungsten properties, the behavior of WO_{3-x} layers under deuterium/helium bombardment and thermal cycling effect in divertor-like conditions, we have produced, by thermal oxidation, thin layers of WO_{3-x} on W substrates which mimic the possible oxidation of tungsten plasma facing components. The produced tungsten oxide layers were characterized using scanning electron microscopy (SEM), transmission electron microscopy (TEM), Raman spectroscopy and X-ray diffraction (XRD) techniques. The thickness of the colored oxide thin layer δ, measured by SEM using focused ion beam cross-section (FIB), follows a parabolic law as a function of the oxidation time. A set of those oxide tungsten thin film samples were separately exposed, at PIIM laboratory (Marseille-France) and in collaboration with the University of Tennessee UT (Knoxville-USA) and Oak Ridge National Laboratory ORNL (Oak Ridge-USA), to D and He plasma beams with energy range from 20 eV to 320 eV and total fluence ~ 4.10^{21} m^{-2} and sample temperatures RT-673 K. At RT, due to D implantation (which has high affinity to bond formation) followed by its deep diffusion [1], preliminary results show a phase transition in the WO_{3-x}, change in the layer color as well as formation of tungsten bronze (D_xWO_3) have been observed. However, the He implantation (that has high affinity to induce the creation of bubbles, holes and nanostructure morphology on W [2]) neither causes surface morphological change on the oxide of tungsten nor changes in its color. However, at 673K, an erosion effect was observed due to He implantation in the oxide layer. Deep analysis on the process of structural damage in surface/bulk and estimation of the erosion rate will be described for both exposures using the coupling of Raman spectroscopy and SEM approaches.

Author Index

Bold page numbers indicate presenter

— A —
Addab, Y: C3-1-9, 1
— B —
Bannister, M: C3-1-9, 1
Brahma, S: C3-1-7, 1
— C —
Cabié, M: C3-1-9, 1
Chen, S: C3-1-7, **1**
Chintalapalle, R: C3-1-8, 1
— D —
Donovan, D: C3-1-9, 1
Duran, J: C3-1-9, 1
— H —
Hijazi, H: C3-1-9, **1**
Huang, J: C3-1-7, 1
— L —
Lu, H: C3-1-7, 1
— M —
Maan, A: C3-1-9, 1
Manandhar, S: C3-1-8, **1**
Martin, C: C3-1-9, 1
McKenzie, D: C3-1-5, **1**
Meyer, F: C3-1-9, 1
— P —
Pardanaud, C: C3-1-9, 1
Pascal, R: C3-1-9, 1
— R —
Rubio, E: C3-1-8, 1