Fundamentals and Technology of Multifunctional Materials and Devices
Room On Demand - Session C3
Thin Films for Energy Applications: Solar, Thermal, and Photochemical

C3-1 Au and Ag Nanoparticle Effects on the Electrical Properties of Pulsed Laser Deposited Cdte/Cds Photovoltaic Thin Films, ***Mehmet Alper Sahiner (mehmet.sahiner@shu.edu)**, J. Emerson, F. Akinlade, M. Herington, V. Castillon,* Seton Hall University, USA

We have used pulsed laser deposition to deposit nanoparticles (Ag, Au) to investigate

the effects of these impurities on the photovoltaic properties of the CdS/CdTe based thin films. The main

objective was to investigate how the inclusion of nanoparticles will affect light scattering in the at the interfaces

and whether the different size and shape of nanoparticles will have a positive effect on the overall electrical

performance of these thin film solar cells. In our previous studies, we have investigated the effects of the

embedded Ag nanoparticles on the photoelectric conversion efficiency on CdS/CdTe based thin film solar cells

as synthesized by Pulsed Laser Deposition (PLD). Silver was shown to enhance the photovoltaic performance

by almost doubling the photovoltaic conversion efficiency of the conventional CdS/CdTe films [1]. A careful

comparison of photovoltaic performance of Au/Si versus Ag embedded thin films of CdS/CdTe on indium tin

oxide coated glass substrates have been performed. Our results on the Ag case revealed electrical

performance of these cells have correlates with the particles density and the particle size on the CdS/CdTe

interface. This study concentrates on the Au and Ag nanoparticle deposition on the CdS/CdTe interface with

varying particle size and distributions. Structural and compositional characterization were performed using

XRD, AFM, and SEM/EDX. Photovoltaic properties were measured using a LabView assisted Keithley

Sourcemeter set-up. The comparison of Ag vs Au nanoparticles on the structure and photovoltaic

conversion efficiency will be presented. Ag and Au nanoparticles have contrasting effects on the

photovoltaic conversion efficiency in terms of their relative coverage at the interface, This will be discussed in

the light of plasmonic resonances and effective light scattering for Ag and Au particles.

[1] Olivia Rodgers, Anthony Viscovich, Yunis Yilmaz, Mehmet Sahiner, "The Effect of Embedded Ag

Nanoparticle on the Photovoltaic Conversion Efficiency in CdTe/CdS Thin Films", American Physical Society Bulletin, X17.13 (2018).

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C3-2 Transparent Thermoelectric TiO_2:Nb Thin Films, *J. Ribeiro, F. Correia,* ***Carlos Jose Tavares (ctavares@fisica.uminho.pt)***, University of Minho, Portugal

The design of a transparent conducting oxide (TCO) material with thermoelectric properties is a promising technology for touch–screen displays and solar cell applications. In this work, TiO_2 doped with Nb thin films were deposited by d.c. magnetron sputtering. Several process parameters were adjusted, such as reactive gas (oxygen) partial pressure and deposition time and temperature, which affect the morphology and crystalline structure of the thin films. Hence, by modifying the optical, electric, thermal and thermoelectric properties of the produced TiO_2:Nb thin films, enables their suitability for thermal energy harvesters in devices in order to render them more sustainable. For optimized deposition conditions, TiO_2:Nb thin films with an optical transmittance up to 85 %, a relatively low electrical resistivity (>10 Ω·cm), low thermal conductivity (<2 $W{\cdot}m^{-1}{\cdot}K^{-1}$), and a high absolute Seebeck coefficient (>200 $\mu V{\cdot}K^{-1}$) corresponding to a power factor of 125 µW·K ·m and ZT figure of merit close to 0.1 were attained, as seen in Figure 1. Both anatase and rutile crystalline phases were discerned in the X-ray diffractograms. Scanning electron microscopy observations provided evidence of a dense microstructure and a smooth film surface with an average thickness of 120 nm. From Figure 2, X-ray photoelectron spectroscopy experiments confirms that Nb^{5+} ions substitute Ti^{4+} in the TiO_2 lattice, providing a charge unbalance to the matrix. Furthermore, due to larger ionic radii, Nb^{5+} scatter phonons more efficiently and reduce the thermal conductivity, which is essential for enhancing the thermoelectric property.

C3-3 Multilayers for Efficient Thermal Energy Conversion in High Vacuum Flat Solar Thermal Panels, *D. De Maio,* Unina and CNR-ISASI, Italy*; C. D'Alessandro, A. Caldarelli, E. Gaudino,* UniNa and CNR-ISASI, Italy*; M. Musto,* UniNa - Università degli studi di Napoli "Federico II", Italy*; D. De Luca,* UniNa and CNR-ISASI, Italy*; E. Di Gennaro,* UniNa - Università degli studi di Napoli "Federico II", Italy*;* ***Roberto Russo (Roberto_russo@cnr.it)***, CNR - ISASI, Italy

The solar thermal flat panel insulated with high vacuum can have excellent efficiency performances in the mid temperature range (150-300°C) if equipped with an optimized selective solar absorber. We present 3 multilayer coatings optimized to work at 100, 200 and 300°C. Optimization has been obtained by maximizing the efficiency at the designed operating temperature by a genetic algorithm. The coatings (based on Cr and Cr2O3) have been deposited by DC reactive magnetron sputtering starting from a Cr target on glass and on 3 industrial copper substrates (OFE, OF, ETP). The single layers have been measured by standard characterization techniques (ellissometry, integrating sphere, AFM, X-Rays Diffraction…), whereas the produced multilayers have been also investigated by using a proprietary system [1] able to measure the absorber efficiency as function of temperature up to the stagnation temperature and above[2]. Influence of several deposition parameters on the multilayer performance will be presented. To enhance the absorptivity the multilayers have been covered with antireflective coatings based on SiO2 and/or SiNx.

[1] R.Russo et al. Optic Express 26 (2018) A480

[2] C. D'alessandro et al. submitted to this conference

C3-4 Development of Efficient Perovskite Solar Cells Under Ambient Conditions via Fine Tuning of Compact TiO_2 Layer, ***Navjyoti Bhagat (navjyotibhagat@gmail.com)***, Guru Nanak Dev University, India*; V. Saxena,* Bhabha Atomic Research Centre, India*; A. Mahajan,* Guru Nanak Dev University, India

Organic inorganic perovskites have attracted a great attention as next generation solar cells due to their excellent properties such as high molar extinction coefficient, low temperature processability, ambipolar nature, large diffusion length and small exciton energies. The compact or blocking layers have been studied extensively in dye sensitized solar cells, however, there are only a few reports on the effect of these layers on perovskite solar cells (PSCs). Herein, we employed a thin compact layer of spin coated TiO_2 (c-TiO_2) (<50 nm) in order to reduce series resistance and improve transmittance. Thethickness of c-TiO_2 (7-35 nm) was optimized by changing the precursor concentration as well as spinning speed. The prepared c-TiO_2 as well as mesoporous layer of TiO_2 (m-TiO_2) were thoroughly characterized using UV-Vis spectroscopy, Raman, Atomic Force Microscopy, Cyclic voltammetry and electrochemical techniques.Further, PSCs were fabricated under ambient conditions with high humidity (~RH 80%) using CuSCN as hole transporting layer (HTL). The power conversion efficiency of the optimized device found to be improved by 50 % on increasing the thickness of ETL from 7 nm to 15 nm.

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