

**Wednesday, May 13**

**2:30 p.m. CT-11 Emissivity Modulating Electrochromic Device**

H. Demiryont, Eclipse Energy Systems, Inc., St. Petersburg, FL

*Invited 40 min. Talk*

Eclipse infrared electrochromic device, IR-ECD, is an all-solid-state, all inorganic vacuum deposited monolithic thin film system functioning as an electrically controlled dimmable mirror in IR region. Maximum reflectance corresponding to bleach condition of the system is around 90% (low-e condition,  $e=0.1$ ). The minimum reflectance reaches near zero in the colored condition of the system (high-e,  $e=1$ ). Average emissivity modulation of Eclipse IR-ECD is 0.8 in the 8-12 micron region. Emissivity modulation is associated with reversible tuning properties of the system at 3 to 5 and 6 to 9 micron regions. Tuning properties of the system are associated with the cooling/heating of the IR-ECD surface. Because of the light weight ( $5\text{g/m}^2$ ), low voltage requirement ( $\pm 1$  Volts), extremely good emissivity control properties around room temperature region and controllable process ability on any substrate by reliable thin film deposition process makes this technology very attractive for satellite-spacecraft thermal control applications. Functionality of Eclipse IR-ECD has been successfully tested in space since March 8, 2007. This paper presents recent developments on the IR-ECD including space functionality test results. Space environmental tests will be reviewed in the paper.

**Wednesday, May 13**

**3:30 p.m. CT-12 New Thermochromic Coatings for Energy Efficient Windows**

C.G. Granqvist, N.R. Mlyuka, and G.A. Niklasson, Ångström Laboratory, Uppsala University, Uppsala, Sweden

Thermochromic materials change their transmittance reversibly at a "critical" temperature. Vanadium dioxide films are well known and have a larger infrared transmittance below the critical temperature than above it. Applications on energy efficient windows have been hampered by two things: the critical temperature is too high (about  $60^\circ\text{C}$ ), and the visible transparency is too low for thicknesses giving good thermochromism. These problems have remained for decades despite much research. This paper shows that magnesium doping increases the visible transmittance substantially and also decreases the critical temperature to a comfortable temperature. Doping with aluminium gives enhanced transmittance but increases the critical temperature somewhat. Specifically, we report recent data on vanadium dioxide films doped with Mg, Al, W, and combinations of these. We believe that these results make thermochromics more viable for window applications. Furthermore, new combinations of electrochromic and thermochromic coatings lead to "smart" windows with new and superior functionality.

**Wednesday, May 13**

**3:50 p.m. CT-13 Boron-Doped Polycrystalline Diamond Electrodes for Electrochemical Applications**

M. Becker and T. Schuelke, Fraunhofer USA, East Lansing, MI; G. Swain, Department of Chemistry, Michigan State University, East Lansing, MI; and J. Asmussen, Department of Electrical and Computer Engineering, Michigan State University, East Lansing, MI

Boron-doped polycrystalline diamond thin films are an excellent electrode material for electrochemical applications including water treatment (destruction of inorganic and organic pollutants, disinfection), electrosynthesis, electroanalytics, bioelectrochemistry and electrochemical energy storage and conversion. This broad variety of potential applications requires the material to be synthesized on various substrate materials, geometries and dimensions. Therefore a tunable microwave plasma assisted chemical vapor deposition (MPACVD) reactor was used to develop coatings for disks, plates, pins and wires made from various metals (titanium, tungsten, niobium) and silicon. Process development results are presented, which address issues such as coating adhesion, mechanical stress reduction, boron concentration and uniformity, thickness uniformity, and microscopic coating material flaws (cracks, voids). In addition the paper presents information on shaping the coated materials to fabricate designed electrodes and on testing them using cyclic voltammetry.

**Wednesday, May 13**

**4:10 p.m. CT-14 Visible Light-Active C-Doped TiO<sub>2</sub> Thin Films for Solar Hydrogen Generation**

M. Schulz, H.Y. Lin, M. Day, and S.I. Shah, University of Delaware, Newark, DE

*Student Sponsorship Applicant*

Photoelectrochemical cells (PECs) have the potential to split water to generate clean-burning hydrogen fuel, using only input power from the sun. Titanium dioxide thin films are excellent candidates for photoanodes in PECs, and substitutionally doping pure TiO<sub>2</sub> with nonmetals such as carbon has been shown to improve visible light response by establishing defect electronic states just above the valence band. We have synthesized a series of modified TiO<sub>2</sub> thin films with atomic concentration up to 4% carbon via a simple, easily controlled pulsed laser deposition technique. Film structure and composition were verified via X-ray diffraction and X-ray photoelectron spectroscopy. UV-Visible absorption spectroscopy and preliminary electrochemical characterization showed improved visible light response over undoped TiO<sub>2</sub>.

**Wednesday, May 13**

**4:30 p.m. CT-15 The Properties of Metal Doped TiO<sub>x</sub> Thin Films Deposited by PVD Method**

M. Horakova, Technical University in Liberec, Liberec, Czech Republic; N. Martin and E. Aubry, Institut FEMTO-ST, Besancon, France; P. Spatenka, Technical University in Liberec, Liberec, Czech Republic and University of South Bohemia, Ceske Budejovice, Czech Republic; and P. Hájková, Technical University in Liberec, Liberec, Czech Republic

For several years, titanium dioxide has gained scientific interests because of its versatile properties like photocatalytic activity. Basically, the photocatalytic process is initiated by the photogeneration of electron/hole pairs in the semiconductor by photon absorption of UV-light. The addition of noble metals into a semiconductor can change its physical properties, thus the photocatalytic activity. The aim of this study is improving photocatalytic efficiency of TiO<sub>x</sub> thin films doped with noble metals. TiO<sub>x</sub> thin films were deposited on glass substrate by DC reactive magnetron co-sputtering at low temperature and *in situ* doped by nanoparticles of silver, gold or copper. The morphology and structure of the films were examined by SEM and XRD. The chemical composition was studied by RBS analysis. The photocatalytic activity was evaluated from decomposition speed of aqueous solution of the Orange 7, (sodium salt of sulphonated azo dye), exposed to UV light. Relations between doped and non-doped films properties, deposition parameters and photocatalytic activity is analyzed. This work was supported by MSMT, project NANOPIN 1M0577 and by GA AV CR, project No. KAN101120701.

**Wednesday, May 13**

**4:50 p.m. L-12 Reactive Magnetron Sputtering of ZnO:Al, A Status Report**

B. Szyszka, V. Sittinger, W. Dewald, A. Pflug, S. Ulrich, A. Kaiser, and W. Werner, Fraunhofer Institute for Surface Engineering and Thin Films IST, Braunschweig, Germany

Transparent and conductive ZnO:Al films to be applied as window layers in thin film solar cells have received strong interest in the last few years. This material competes against SnO<sub>2</sub>:F by AP-CVD or LP-CVD and against ZnO:B by LP-CVD. For ZnO:Al, on the other hand, the deposition technique most relevant for industrial production is PVD by large area inline magnetron sputtering. The state-of-the-art for industrial manufacturing at the present time is ceramic target sputtering using sintered target materials either from planar or rotatable sintered targets since this technique allows for excellent process stability at acceptable cost level at this time. The reactive magnetron sputtering of ZnO:Al, on the other hand, has not achieved industrial relevance for mass production up to now due to the severe demands on closed loop control. This hindered the integration in processing lines for mass production in spite the fact that superior film properties result from reactive sputtering in terms of low absorption, high conductivity and good light scattering. Furthermore, a substantial decrease of costs can be expected when cost effective metallic Zn:Al targets are used instead of ceramic ZnO:Al<sub>2</sub>O<sub>3</sub> compounds. This paper gives a report on the status of reactive AC magnetron sputtering using the 60 x 100 cm<sup>2</sup> in-line coater at Fraunhofer IST. We report on the performance of ZnO:Al coatings and thin film solar cells utilizing a variety of ZnO:Al films and also on the latest developments on the PLC based closed loop control algorithms for fully automatic operation of the coater.