

# Tuesday Afternoon Poster Sessions

## Advanced Surface Engineering

Room: Hall 3 - Session SE-TuP

### Advanced Surface Engineering Poster Session

#### SE-TuP1 Characterizations of Normal Incidence Polarizing Beam-Splitter Deposited by Glancing Angle Deposition, *Y.J. Park, K.M.A. Sobahan, J.J. Kim, C.K. Hwangbo*, Inha University, Republic of Korea

Glancing angle deposition (GLAD) is a sophisticated technique to fabricate engineered nanostructured thin films for next generation nano and micro devices. In this technique, oblique angle deposition and substrate rotation are employed to control the shapes and porosity of the films, caused by a self-shadowing effect and surface diffusion. Recently, the applications of the properties of the GLAD thin films become the basis of a wide array of industrial components including high-speed gas sensors, optical thin films or nanoporous coatings.

In this study, we investigate the optical and structural properties of normal incidence polarizing beam-splitter. It is realized as a combination of quarter-wave plate, Bragg reflector and opposite quarter-wave plate. The zigzag microstructures of the quarter-wave plates as well as the opposite quarter-wave plates and the helical structure of the Bragg reflector are fabricated by electron beam evaporation using GLAD technique and TiO<sub>2</sub> material is used in this purpose. The physical thicknesses of the opposite and quarter-wave plates are calculated using their anisotropy. It is found that the normal incidence polarizing beam-splitter reflects the p-polarized light while transmits the s-polarized light with wavelength lying in the Bragg regime. The structural and surface morphology of this device are also investigated using scanning electron microscope.

#### SE-TuP2 Modified Glancing Angle Deposition for Making Nanostructured High Porous SiO<sub>2</sub> Thin Films, *K.M.A. Sobahan, Y.J. Park, C.K. Hwangbo*, Inha University, Republic of Korea

Glancing angle deposition (GLAD) is a physical evaporation technique widely used to fabricate nanostructured thin-films materials with controllable shapes and porosity, which is achieved by a self-shadowing effect and surface diffusion. By taking advantage of the versatility of the GLAD technique, it is possible to engineer the materials with unique properties for added value in such areas as optical thin films or nanoporous coatings, high-speed gas sensors, and chemical devices. GLAD thin films can also serve as the foundation of many different types of nano and micro devices.

In this communication, we report the nanostructured porous SiO<sub>2</sub> thin films fabricated by modified GLAD technique. The optical properties of the SiO<sub>2</sub> films fabricated in this technique are investigated and as an application, the antireflection coating (AR) for visible wavelength is designed and fabricated. It is seen that the average reflectance of the AR coating is below 0.04%. The microstructures and the surface morphology are also investigated by using a scanning electron microscope (SEM).

#### SE-TuP3 Microstructure and Corrosion Resistance of Nano-Crystalline ZrTiN Films on AISI 304 Stainless Steel Substrate, *Y.W. Lin*, Instrument Technology Research Center, Taiwan, *J.H. Huang, G.P. Yu*, National Tsing Hua University, Taiwan

This study investigated the effect of ratio of Zr/(Zr+Ti) on microstructure and corrosion resistance of ZrTiN thin films. ZrTiN thin films were deposited by reactive magnetron sputtering based on our previous optimum coating conditions (substrate temperature, system pressure, nitrogen flow etc.) for TiN and ZrN thin films. The ratios of Zr/(Zr+Ti) were dominating by changing Ti and Zr target power, and found out the optimum composition with desired properties. The ratio of N/Ti/Zr and composition of ZrTiN thin film were analyzed by X-ray Photoelectron Spectroscopy (XPS) and Rutherford Backscattering Spectrometer (RBS). In terms of phase formation, there were two types of coatings were considered, single-phase solid solution of Zr<sub>x</sub>Ti<sub>1-x</sub>N and interlacing nucleus of TiN or ZrN in the matrix of Zr<sub>x</sub>Ti<sub>1-x</sub>N. The thickness of ZrTiN films measured by scanning electron microscope (SEM) was greater than 900 nm. The composition depth profiles measured by Auger electron spectrometer (AES) indicated that the compositions in the ZrTiN films were uniform from the film surface to the 304 stainless steel substrate. The crystal structure of the ZrTiN films was determined by X-ray diffraction (XRD) using a M18XHF-SRA diffractometer with Cu K<sub>α</sub> radiation. Reflection line of ZrTiN (002) peak is observed between those of TiN (002) peak and ZrN (002) peak, similarly, reflection line of ZrTiN (111) peak is observed between those of TiN(111) peak and ZrN(111) peak, respectively. The corrosion resistance of ZrTiN films on commercial AISI 304 stainless steel has been investigated by

electrochemical measurement. The electrolyte, 0.5 M H<sub>2</sub>SO<sub>4</sub> containing 0.05 M KSCN, was used for the potentiodynamic polarization. The potentiodynamic scan was conducted from - 800 to 800 mV (SCE) with scan rate ranging from 10 to 600 mV/min. The variation of Zr/(Zr+Ti) ratio on the microstructure and corrosion resistance of ZrTiN film was investigated.

#### SE-TuP4 Light Out-Coupling Characteristics Based-on the Interfacial Electronic Structure of MoO<sub>x</sub>-doped Fullerene, a Potential Hole Ohmic-Contact Layer for Organic Semiconductor, *J.T. Lim, J.W. Kwon, G.Y. Yeom*, Sungkyunkwan University, Korea

Recently, the interest on the ohmic contact between the metal-organic interfaces has been actively increasing to inject charge carriers between electrodes and an adjoining organic layers more efficiently. Among those contact, the hole-injecting properties without a barrier height between anode and a hole-injecting layer are very important for driving the devices to a high brightness and a high luminous efficiency in organic semiconductors, such as the organic light-emitting diodes, organic solar cells, and organic thin film transistors. Here, we reported on the new ohmic-hole contact system of MoO<sub>x</sub>-doped fullerene. The phosphorescent organic light-emitting diode with fullerene doped with 10% MoO<sub>x</sub> showed the maximum brightness of 86500 cd/m<sup>2</sup> and the power efficiency of 15.6 lm/W at a luminance of 100 cd/m<sup>2</sup>. The improvement of the light out-coupling property by inserting the MoO<sub>x</sub>-doped fullerene layer between anode and a hole-transporting layer is due to the formation of an ohmic contact without the barrier height in a hole injection ( $\Phi_B^h$ ) as well as the raising of the band banding by pinning Fermi levels in the interfaces. The mechanism for the ohmic hole-injecting characteristic from anode to MoO<sub>x</sub>-doped fullerene was proved from an ultraviolet photoemission spectroscopy (UPS) spectra. In UPS spectra, the highest occupied molecular orbital (HOMO) level of the interface formed between two materials nearly approaches to Fermi level of anode.

#### SE-TuP5 Novel Top-Down Fabrication Technique for Metallic Nanoparticles Using Microsphere Self-Assembly and Oblique Angle Thin Film Deposition, *M.A. Roddy, E.M. Kirkpatrick, S.R. Kirkpatrick*, Rose-Hulman Institute of Technology

Metallic nanoparticles are of significant interest to the biomedical, electronics, optical, and magnetic fields. We have worked to develop a novel technique to fabricate nanoparticles on the order of 100 – 1000 nm. The process uses a self-assembled planar array of polystyrene microspheres[1] as a structured template for oblique angle deposition of a thin film, such that the tops of the spheres are covered with ‘caps’ (see Attachment 1). The spheres provide mutual shadowing from deposition, which determines the nucleation sites for metallization resulting in semi-spherical and hemispherical caps. Nanoparticle caps of both SmCo and chrome were fabricated. Chrome caps were prepared by allowing a mixture of 800 nm microspheres and DI water to dry on a substrate (glass, oxidized silicon, or bare silicon). 100 nm of chrome was then sputtered on the microspheres at angles of 80, 75, and 70 degrees normal to the surface. The sputtering parameters were base pressure of 2E-8 torr, sputter gas pressure of 2E-3 torr, and power of 300 W. In order to characterize the resulting nanoparticles via SEM the polystyrene was removed either by methanol or oxygen plasma ashing. A similar method was used for the SmCo samples, however, both an underlayer and overlayer of 15 nm NiCr was deposited head-on in order to prevent oxidation of the SmCo. Morphology of the samples depended on deposition angle and the deposition direction compared to the orientation of the self-assembled template and the resulting particles ranged in size from 350-700 nm.

#### SE-TuP6 Tribological Behaviour of TiAlN/TiAlN/Pt Multilayers Deposited on Stainless Steels, *M. Flores, J. Garcia, E. Rodriguez*, Universidad de Guadalajara, Mexico, *L. Huerta*, Universidad Nacional Autonoma de México, *E. De las Heras*, Instituto Nacional de Tecnología Industrial, Argentina

In the present work we report the results of studies about the influence of Pt layers on the wear resistance of TiAl/TiAlN multilayers deposited on 316L stainless steel by magnetron sputtering using targets of TiAl and Pt. Coating types investigated included TiAlN, TiAlN/TiAl, TiAlN/TiAl/Pt and duplex coatings with substrates nitrided by pulse plasma nitriding. The thickness of the Pt layers was from 50 nm to 200 nm and the period of TiAlN/TiAl multilayer from 250 to 500 nm. The friction and wear tests were performed on a ball-on-flat tribometer and conducted in dry (unlubricated) conditions at room temperature. The loads used were from 2N to 10N and the oscillating frequency from 1 Hz to 5 Hz. The structure, composition and thickness of multilayers were studied by means of XRD, RBS and ellipsometry analysis. The surface topography and wore surface

were studied by means of optical microscopy and profilometry. The results indicate that coefficient of friction (COF) of TiAlN coatings decreased when metal layers are introduced.

**SE-TuP7 Physical Processes for Low Temperature Plasma Activated Wafer Bonding.** *T. Plach, K. Hingerl,* Johannes Kepler University, Austria, *V. Dragoi, G. Mittendorfer, M. Wimplinger,* EV Group, Austria

Low temperature plasma activated direct wafer bonding (LTPADWB) for Si-SiO<sub>2</sub> interfaces is a process that lowers the required annealing temperatures necessary for reaching high bond strength. Bulk strength can be realized by plasma activation with subsequent annealing at 300°C. The mechanism behind this improvement is still under discussion.

At this temperature, half of the bulk strength is reached already with conventional wafer bonding. The low temperature steps for the hydrophilic process are interpreted as follows: Up to 100°C the substrate surfaces are held together via van der Waals interaction which is mediated by a few monolayers of water. In the range of 100-200°C the water diffuses away from the interface both along the interface and through the oxide into the crystalline bulk, where it reacts with the silicon and forms oxide. The remaining half of the bond strength is usually attributed to a closing of gaps at the interface[1], which starts at the softening temperature of the thermal oxide at around 850-900°C.

To clarify the mechanism for this commercially available process, different bonding experiments were performed to evaluate the lifetime of the surface activation and the achievable bond strength when using substrates with various orientations. Interfaces of bonded wafer pairs were investigated by transmission electron microscopy (TEM). TEM images clearly show that there is no discernible interface between the native oxide on one side and the thermal oxide on the other side.

By covering half of the wafer during plasma activation, comparisons between the activated and non-activated region could be made by atomic force microscopy, by spectroscopic ellipsometry, by Auger analysis and by X-ray photoelectron spectroscopy.

It was found that the top surface stoichiometry is chemically changed, which favors bonding. Finally a model for the mechanism that explains the experimental results will be presented.

*Keywords: wafer bonding; plasma; low temperature*

**References**

[1] Q.-Y. Tong, U. Gösele, *Semiconductor Wafer Bonding: Science and Technology*, Wiley, (1998)

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