Thin Film
Room: Southwest Exhibit Hall - Session TF-TuP

Thin Film Poster Session I

TF-TuP2 Electrical and Optical Properties of Very Thin Ag Films with Surface and Interface Nanolayers, ***M. Kawamura***, *K. Nishida, R. Kiyono, Y. Abe, K. Sasaki*, Kitami Institute of Technology, Japan

We have attempted improvements of thermal stability of Ag thin films which are candidates of electrodes in various electronic devices. Consequently, we have found that an introduction of very thin (about 3 nm thick) Al oxide surface and interface layers was very effective. For example, we confirmed a high thermal stability up to 600 ^{o}C even the Ag layer thickness was reduced to 50 nm in Al/Ag/Al films.

In the present work, we have further reduced the thickness of Ag layer in Al/Ag/Al films to obtain high transparency and investigated possibility to apply them as transparent electrodes. As a result, the Ag layer thickness could be reduced to 10 nm in Al/Ag/Al films, keeping a low electrical resistivity. On the other hand, Ag single layers thinner than 14 nm were discontinuous state having a high electrical resistance. Transmittance above 70% was obtained for the Al/Ag(10nm)/Al films. In addition, the property change of the films was found to be very little even after keeping them in air at 60 ^{o}C for 300 hrs, or in pure water at room temperature for 200 hrs. Consequently, it is found that the Al/Ag/Al thin films have good properties as transparent conductive electrodes.

TF-TuP3 Synthesis and Characterization of Cubic BC_2N Deposited by Reactive Laser Deposition, ***H.A. Castillo***, Universidad Nacional de Colombia Sede Manizales, Colombia, *J.M. Vélez,* Universidad Nacional de Colombia Sede Medellin, Colombia, *W.H. de la Cruz*, Universidad Nacional Autónoma de México

Boron carbide nitride is considered a very important material, used for industrial applications due to their high hardness. Cubic BC_2N films were synthesized in a laser ablation system using a target of B_4C with 99.9% wt. Films were grown on (111) silicon wafers in an ultra high vacuum system with a base pressure in a low 1 *10^{-9} Torr range. Target ablation was performed by means of a KrF excimer laser (λ=248 nm). During the grown process, the substrate temperature was varied in order to identify the influence of this parameter in the structure, composition and morphology of the coating. The composition, bonding configuration was obtained by X-ray photoelectron (XPS) and the mechanical properties hardness and Young's modulus were determined using a Berkovich nanoindenter. Structural analyses with X-ray diffraction exhibited only 111, 200 and 220 lines of the cubic lattice.

TF-TuP4 Comprehensive Comparison of Electrical and Reliability Characteristics for Various Copper Barrier Films, *Y.J. Cheng,* ***C.-T. Jung***, *J. Wu*, NCNU, Taiwan, Republic of China

The physical, electric and reliability characteristics of various Copper (Cu) barrier layers, including SiC, SiCN, SiCO, SiCNO, and SiN, were investigated. The reliability results associated with film characteristics were also reported in this work. The SiN film still shows the better Cu barrier performance, adhesion strength with Cu, and electromigration (EM) reliability, but its dielectric constant is too high. Nitrogen-doped or oxygen-doped silicon carbide barrier films (SiCN or SiCO) can reduce the dielectric constant, but show a traded-off reliability performance. A newly developed SiCNO film with doping nitrogen and oxygen can meet the better reliability (EM/SM) requirements at the same time, and has a comparable physical and electrical performance to the SiN film.

TF-TuP5 Growth of Silicon-Germanium-Carbon Alloys Using Modified Laser Ablation, ***J.G. Quiñones Galván***, *F. de Moure Flores, A. Hernández Hernández, S. Cerón Gutiérrez, K. Nieto Zepeda, M.A. Meléndez Lira*, CINVESTAV-IPN, Mexico

Laser ablation technique allows depositing thin films with the same stoichiometry of the target material. The common use of solid targets is a limitation when there is a need to produce ternary alloys. In order to overcome that limitation we designed a modification of the laser ablation technique to employ powders as target.[1]

The incorporation of carbon in a SiGe alloy is an alternative for achieving larger band gap and strain compensation. The main problem to control substitutional carbon concentration in SiGeC is the low solubility coefficient of carbon in silicon. Laser ablation technique allows exploring deposition parameters far from the equilibrium that could improve the content of substitutional carbon.

In this work we present the growth and characterization of thin films of $Si_{1-x-y}Ge_xC_y$ alloys in the compositions range $0.27 \leq x \leq 0.29$ and $0.01 \leq y \leq 0.03$ deposited at different temperatures using the Modified Laser Ablation technique.

The samples where characterized by scanning electron microscopy, atomic force microscopy, X ray diffraction, energy dispersive X-ray spectroscopy, Raman, photoluminescence and photoreflectance spectroscopies. Results indicate the modification of the electronic properties of the alloys depending on the carbon content.

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TF-TuP6 Interface and Properties of ALD Ta_2O_5 Films on Si (100) and GaAs (100) Surfaces, ***T. Gougousi***, *J.W. Lacis*, UMBC

Tantalum pentoxide (Ta_2O5) films have been deposited using an Atomic Layer Deposition (ALD) process based on the reaction of pentakis dimethyl amido tantalum (PDMAT) and H_2O at 250°C. Films were deposited on native oxide Si(100) surfaces and native oxide and etched GaAs(100) surfaces. Linear growth at ~0.6 Å/cycle has been confirmed using spectroscopic ellipsometry. Atomic Force Microscopy indicates that the films are smooth and x-ray diffraction data indicate that the as-deposited films are amorphous, and begin to crystallize after anneals at 800°C (3 min, Ar). These observations are mirrored in the infrared spectra. Film composition has been studied using x-ray photoelectron spectroscopy (XPS) and it has been found that the films are slightly over oxidized. The interface of films deposited on native oxide and etched GaAs surfaces has also been studied using XPS and high resolution transmission electron microscopy. Data from both techniques indicate that an interface cleaning mechanism similar to that observed for other amide based ALD processes may be present.

TF-TuP7 The Mechanical Properties and Thermal Stability of CrZrSiN/AlN Multilayer Coatings Synthesized by Closed Field Unbalanced Magnetron Sputtering, ***S. Lee***, Korea Aerospace University, Republic of Korea

In this work, for the high temperature applications, CrZrSiN/AlN multilayer coatings with various bilayer thicknesses (Λ) were synthesized using a closed-field unbalanced magnetron sputtering (CFUBMS) and their chemical composition, crystalline structure, morphology, mechanical properties, and thermal stability were characterized by glow discharge optical emission spectroscopy (GDOES), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), scanning electron microscopy (SEM), atomic force microscopy (AFM), and nanoindentation. Also, the thermal stability of the CrZrSiN/AlN multilayer coatings was evaluated and compared with that of the CrZrSiN coatings by annealing the thin films at temperatures between 500 ℃ and 1200 ℃ for 30 min in air and under vacuum. The experimental results revealed that the hardness of the CrZrSiN/AlN coating was much superior to that of the CrZrSiN coating after annealing at various temperatures due to the presence of alternating AlN thin films. Furthermore, in the CrZrSiN/AlN coating with the bilayer thicknesses of 2.4 nm, the relatively high hardness of 28.3 GPa was maintained even after annealed at 1100 ℃. The detailed experimental results will be presented.

TF-TuP8 First Reset Resistance Switching Characteristics with the Crystallinity of Ta_2O_5 Films, *H.-C. Sohn,* ***H.D. Na***, *K.-M. Lee, J.G. Kim, S.-H. Lee*, Yonsei University, Republic of Korea

In this work, we investigated the effect of the crystallinity on the first reset resistance switching characteristics of Ta_2O_5 films. Ta_2O_5 films annealed by Rapid Temperature Process (RTP) at above 650 ℃ were changed from amorphous to poly-crystal structure. The post-annealing temperature of above 650 ℃ produced the resistance switching behavior of first reset process, indicating the disappearance of forming process due to high current level. For indentifying the formation of local conductive path, the ratio of High Resistance States (HRS) and Low Resistance States (LRS) in 200 x 200 um^2 pattern of Ta_2O_5 was measured with the regular interval of 25 points at read voltage of 0.2 V. The crystallinity of Ta_2O_5 films with the annealing temperature was measured by X-Ray Diffraction (XRD) and Transmission Electron Microscopy (TEM). TEM and Fast Fourier Transform (FFT) images showed the nano-crystal structure in local region of Ta_2O_5 film annealed at 650 ℃. We expected that the local crystal structure in Ta_2O_5 films formed by RTP is expected to be closely related to the local conductive path.

TF-TuP9 Preparation and Characterization of Ta-doped Indium Tin Oxide Films Deposited by DC Magnetron Sputtering, ***S.M. Chung***, *J.H. Shin, W.-S. Cheong, C.-S. Hwang, S.H. Park, K.I. Cho*, ETRI, Republic of Korea

Transparent conductive oxide (TCO) films have been widely used as transparent electrodes for various applications such as smart windows, flat panel display (FPD), touch panel, light-emitting diodes, optical wave guides, and solar cells. It is well known that the TCO films require the properties of wide band gap (>3.0eV), high conductivity, and high transmittance (>80%) in the visible range. Current applications of the TCO films emphasize minimizing resistivity. Among the technologies available for producing ITO films, DC magnetron sputtering can produce high quality films and be adapted to large-area coatings. In general, the characteristics of indium tin oxide (ITO) depend on its oxidation state and the content of impurities. The carrier concentration may also be modified by the dopant activation state because a donor atom can substitute the lattice site producing more than one free electron to increase conductivity. Ta also can be a donor because the indium is replaced by Ta in the In_2O_3-matrix ITO film, which releases one free electron contributing the electrical conductivity.

In this work, ITO and ITO:Ta films were deposited on corning glass substrates by DC magnetron sputtering using ITO and Ta-doped ITO targets, respectively, at room temperature. Effects of Ts dopant on the structural and opto-electrical properties of the ITO films were investigated. The detailed results will be revealed in this presentation.

TF-TuP10 Deposition of Ga-doped ZnO Films by Atomic Layer Deposition Using Ozone as the Oxygen Source, ***H. Yuan***, *B. Luo, S.A. Campbell, W.L. Gladfelter*, University of Minnesota

Gallium-doped ZnO (GZO) films were grown on Si and SiO_2/Si substrates at 250°C by atomic layer deposition using diethylzinc as zinc precursor and ozone as the oxygen source. Trimethylgallium were used as the dopant precursor, and two approaches to doping were studied. In one a nanolaminate was formed by interspersing a trimethylgallium/ozone cycle in between the diethylzinc/ozone cycles. The overall gallium concentration depended on the number of diethylzinc/ozone cycles. The second approach involved co-injection of both metal precursors in which their relative concentrations were controlled by adjusting the precursor vessel temperature. The influence of the deposition method on the composition, structural, electrical, and optical properties of the GZO thin films as a function of doping metal concentration will be reported. X-ray diffraction patterns showed all the samples were polycrystalline and exhibited (0001) preferential orientation. The carbon content of the films was below the detection limit of Auger electron spectrometry. The lowest resistivity (4.7×10^{-4} Ω•cm) of the as-deposited films was obtained through use of the co-injection process. The average optical transmission was over 85 % in the range of 400-800 nm and the optical band gap increased with increasing doping in accordance with the Burstein-Moss effect. The effect of rapid thermal annealing will be presented.

TF-TuP11 Fabrication and Structural Analysis of W-Ti-O Thin Films, ***N.R. Kalidindi***, *S.K. Gullapalli, R.S. Vemuri, F.S. Manciu, K.B. Karuppanan, C.V. Ramana*, University of Texas at El Paso

Semiconductor oxide based chemical sensors are widely used for detecting very small amounts of toxic gases. Tungsten (W) oxide thin films have been used for measuring small amounts of H_2S gas. The present work was performed on tungsten-titanium mixed oxide (W-Ti-O) thin films for application in H_2S sensors. W-Ti-O were deposited by r.f. magnetron sputtering from a W-Ti alloy target with 5 % (wt %) Ti. W-Ti-O films were grown at different substrate temperatures ranging from 30 to 500ºC. All the films were grown with argon/oxygen ratio of 1:9. Structural characterization was performed using X-ray diffraction (XRD) and scanning electron microscopy (SEM) measurements. The results indicate that the W-Ti-O films grown up to the substrate temperature of 200ºC were amorphous while films grown at 300-500 ºC were crystalline. The peak broadening was found to increase with increase in substrate temperature from 300ºC to 500ºC due to the increase in disorder with the inclusion of Ti. XRD and SEM results confirm significant disordering at the Si-film interface at higher processing temperatures. Based on the results, which will be presented and discussed, the effect of substrate temperature on the microstructure of W-Ti-O films is established.

TF-TuP12 O K and Si (Ge) $L_{2,3}$ ($M_{2,3}$) Spectra of Non-Crystalline Plasma-Deposited Thin Film nc-SiO_2 and nc-GeO_2, ***D.J. Zeller***, *K. Wu, G. Lucovsky*, North Carolina State University

Four-fold coordinated Si-atoms in nc-SiO_2 are bonded to two-fold coordinated O-atoms in a bent 3-atom group with Si 3d-associated T_{2g} symmetries on the Si-atoms [1]. These constrain the dihedral angles brinding O-atoms, and contribute to medium range order (MRO) with correlation a length of ~0.4 to 0.45 nm, and a coherence length of ~1 nm, each obtained from analysis of the first sharp diffraction peak in X-ray/electron diffraction [2]. Similar considerations apply to nc-GeO_2. Analysis of O K edge spectra for nc-SiO_2 reveals conduction band states with 3s-state symmetries at the band edge, and stronger 3d-state symmetries at higher energy. The s-state features define the respective band gaps of ~ 9 eV for nc-SiO_2, and ~6 eV for nc-GeO_2 In nc-SiO_2, the energy difference between band edge non-degenerate A_1 features, and the triply degenerate T_2 and doubly degenerate E d-state features is ~3 eV, whereas in c-Si it is smaller, ~1 eV. The relative energies are these features are the same as band edge features obtained from transmission and reflectivity studies in the visible and VUV where this d-state character was not previously recognized [3]. This correspondence derives from O 1s core hole localization, and a coherent process whereby these core states are filled by electrons from valence band O 2p p states. Additionally, there is a one-to-one correspondence between Si A_1 features and the Si T_{2g} features in the O K edge and the Si $L_{2,3}$ spectra of SiO_2. Studies of $L_{2,3}$ transitions by electron energy loss spectroscopy (EELS) did not detect the Si 3s features in the 100 to 104 eV regime of nc-SiO_2, or in the 98 to 100 eV regime of c-Si. Analysis of O K and $L_{2,3}$ spectra are based on the charge transfer multiplet (CTM) formalism [4]. The ground state is $Si2p^63d^0\underline{L}$ + $Si2p^63s^0\underline{L}$, where $\underline{L}$ describes a coherent process in which Si 1s core level holes are neutralized by electrons from the O 2p states. Ground states have ^1A symmetries, excited states are $Si2p^53d^1\underline{L}$ + $Si2p^53s^1\underline{L}$ with ^1F and ^1P symmetries, respectively. Degeneracies are lifted by different J values associated with the orbital angular momentum. Similar spectral features are observed for nc-plasma-deposited GeO_2, and these films exhibit the same correspondence between Ge 4s- and 4p-derived features in the O K edge and the Ge $M_{2,3}$ edge.

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TF-TuP13 High Temperature Oxidation Performance of Multilayered $Al_xTi_{1-x}N$/CrN Coatings, ***Y.Y. Chang***, *W.H. Wu*, Mingdao University, Taiwan, Republic of China

The high temperature oxidation behavior of $Al_xTi_{1-x}N$ and multilayered $Al_xTi_{1-x}N$/CrN coatings was studied. These coatings were synthesized by cathodic-arc evaporation with plasma enhanced duct equipment. Chromium and AlTi alloy alloy (70/30 at. % ratio) cathodes were used for the deposition of $Al_xTi_{1-x}N$/CrN coatings. During the coating process of multilayered $Al_xTi_{1-x}N$/CrN, CrN was deposited as an interlayer. The multilayered structure was obtained by regulation of cathode power at a constant rotation speed of sample holders. The nanolayer thickness and alloy content of the deposited multilayered coating were correlated with the emission rate of alloy cathode materials. In this study, field emission scanning electron microscope (FESEM), and X-ray diffraction using glancing angle parallel beam geometries were used to characterize the microstructure of the deposited films. High resolution transmission electron microscope (HRTEM) was used for nanolayered structure analyses of the multilayered $Al_xTi_{1-x}N$/CrN coatings. For the high temperature oxidation test, the coated samples were annealed in the temperature range 700~1000 ºC in air for 2 hours. After oxidation, the deposited $Al_xTi_{1-x}N$ had completely transformed to TiO_2 and Al_2O_3 at 900 ºC. Interestingly, the multilayered $Al_xTi_{1-x}N$/CrN possessed superior oxidation resistance than the graded $Al_xTi_{1-x}N$. The different oxidation mechanisms of $Al_xTi_{1-x}N$ and multilayered $Al_xTi_{1-x}N$/CrN at high temperature are developed in this study.

TF-TuP14 Formation of Ti-Doped DLC Films by Inert-gas Ion Beam Assistance in a $C_{10}H_8$ Atmosphere, ***S. Narita***, *I. Takano*, Kogakuin University, Japan

Diamond-like carbon (DLC) has the amorphous structure that is chiefly composed by graphite (sp^2) and disordered graphite (sp^3) state. Therefore mechanical properties of DLC generally show high hardness and low friction. DLC film has been prepared by various method of chemical vapor deposition (CVD) or physical vapor deposition (PVD) including the sputtering method. Commercial applications of DLC have been already performed as engine parts of an automobile or surface coating of a hard disk.

In this study, Ti-doped DLC films were formed using He^+ or Ar^+ ion beam assistance in a naphthalene ($C_{10}H_8$) atmosphere. The formation conditions of DLC film were changed with ion-beam accelerating voltage and current density. Ti doping was performed by using the electron-beam deposition method with Ti evaporation rate from 0.0 to 0.2 nm/sec. The mechanical properties of hardness and friction coefficient were determined using the dynamic micro knoop hardness tester and the ball-on-disk tribotester respectively. Atomic concentration and structure of the films were

investigated by X-ray photoelectron spectroscopy, X-ray diffraction and Raman spectroscopy.

The suitable mechanical property of DLC films was obtained by the condition with accelerating voltage of 5 kV at current density of 10 μA/cm^2. The maximum hardness was 5.37 GPa using Ar^+ ion beam, while the minimum friction coefficient was 0.117 using He^+ ion beam. It was clear that properties of DLC film was changed by ion species. In the case of Ar^+ ion beam, the higher hardness film contained much sp^3 state, while the film with lower friction coefficient contained much sp^2 state. From the other side the higher hardness film has a large crystal grain size as compared with the film with lower friction coefficient.

TF-TuP15 On the Optics of Thin Films Applied in Aerospace Telescope, ***C.N. Hsiao***, *H.P. Chen, P.K. Chiu, Y.W. Lin, W.H. Cho, F.Z. Chen,* National Applied Research Laboratories, Taiwan, *D.P. Tsai*, National Taiwan University

Optical thin films designed for space grade multi-spectral assembly in CMOS sensor and reflective Ag mirror were deposited on radiation-resistant glass by ion-beam-assisted deposition for a Cassegrain-type aerospace telescope . The patterned multi-spectral assembly contained the blue, green, red, near infrared, and panchromatic multi layers high/low alternated dielectric band-pass filters arrays in a single chip which was fabricated by photolithography process. The corresponding properties of the films were investigated by in-situ optical monitoring, ellipsometry, spectrometry, and high-resolution transmission electron microscopy. It was found that the average transmittances are above 88% for the multi-spectral assembly, with a rejection transmittance below 1% in the spectral range of 350~1100 nm. The average reflectance of the Ag mirror (with a protective interference coating) is boosted above 99% in visible spectrum. The polarization sensitivity of the optical payload is below 5 %. Furthermore, to estimate the optical stability of optical thin films for aerospace applications, a space environment that the satellite orbiting above the earth surface at an altitude near 900 kilometers were simulated by Co^{60} gamma (g) radiation test (total dose effects) and thermal vacuum test (pressure below 10^{-7} Torr with thermal cycles).The optical stability of the films with the environmental test will be discussed.

TF-TuP16 Modification of Band Gap Structure of Cu-implanted TiO_2 Catalytic Thin Films by using Metal Plasma Ion Implantation Technique, *D.Y. Wang,* Mingdao University, Taiwan, ***C.C. Yen***, *L.S. Chang,* National Chung Hsing University, Taiwan, *M.H. Shih,* Mingdao University, Taiwan, *H.C. Shih*, National Chung Hsing University, Taiwan

The anstaes TiO_2 thin film has long been identified as the potential photocatalytic materials for various industrial applications. The Cu-implanted TiO_2 catalytic films were prepared by the sol-gel process in conjunction with the metal plasma ion implantation (MPII) technique at an acceleration voltage of 20 keV with various ion dosages. The surface chemical states and compositions of Cu-implanted TiO_2 films were investigated by XPS. The optical band gap of the films was calculated by using Tauc formula. The photocatalytic activity was evaluated by the photodegradation of methylene blue (MB) under visible light irradiation. The correlation between the band gap structure and the photocatalytic behaviors of Cu-implanted TiO_2 were investigated . The electronic band structure and the location of Cu atom in anatase TiO_2 were studied by the first-principle calculations based on the density functional theory. The result demonstrated the dependence of the band gap structure on Cu dosage, which induced the formation of impurity energy levels in the band gap.

Keywords: TiO_2, band structure, photocatalysis, MPII.

TF-TuP17 Nanofabrication of Insulated Scanning Probe Microscopy for Electromechanical Imaging in Liquid Solutions, ***J.H. Noh***, University of Tennessee, *M. Nikiforov, S.V. Kalinin,* Oak Ridge National Laboratory, *A.A. Vertegel,* Clemson University, *P.D. Rack*, University of Tennessee at Knoxville; Oak Ridge National Laboratory

The fabrication and electrical and electromechanical characterization of insulated scanning probes have been demonstrated in liquid solutions. The silicon cantilevers were sequentially coated with chromium and silicon dioxide, and the silicon dioxide was selectively etched at tip apex using focused electron beam induced etching (FEBIE) with XeF_2 The chromium layer acted not only as the conductive path from the tip, but also as an etch resistant layer . The relevant nanofabrication issues relative to the metallization and the insulator deposition process have been discussed. This insulated scanning probe fabrication process is compatible with any commercial AFM tip and can be used to easily tailor the scanning probe tip properties because FEBIE does not require lithography. The suitability of the fabricated probes is demonstrated and discussed by imaging of standard grid as well as piezoresponse force microscopy (PFM) and electrical measurements .

TF-TuP18 The Observation of Strain-Induced InN Nanorods Hetero-Epitaxially Grown by MOMBE, *F.-I. Lai, W.-T. Lin,* Yuan-Ze University, Taiwan, *W.-C. Chen, C.N. Hsiao,* National Applied Research Laboratories, Taiwan, ***S.-Y. Kuo***, Chang Gung University, Taiwan, *H.C. Hsu*, National Cheng Kung University, Taiwan

In this study, we discussed the evolution of morphology and crystal structure of wurtzite indium nitride (InN) hetero-epitaxially grown on GaN/sapphire(0001) by metal-organic molecular beam epitaxy (MOMBE) system with growth temperature. In order to investigate the influences of growth temperature, the stoichiometry of In/N was identical ~1:1 during the InN growth. The optical and structural properties of InN films samples were characterized by temperature-dependence photoluminescence (PL), field-emission scanning electron microscopy (FE-SEM) and x-ray diffraction (XRD). With increasing growth temperature, the surface morphology of InN varied from 1-dimensional (1D) nanorods to 2-dimensional-films. XRD results reveal that the strain of InN were released while increasing growth temperature. The PL emission peaks of InN nanorods and films were about 0.77 eV and 0.83 eV, respectively. .In addition, it is noteworthy that the interface between GaN and InN nanorods exist massif-like structure as growth at lower temperature. These observation implied that the formation of 1D InN nanorods was ascribed to the strain-induced mechanism and will be discussed in detail.

TF-TuP19 Protecting Polymers from the Natural Space Environment with Films Grown Using Atomic Layer Deposition, ***M. Groner***, ALD NanoSolutions, Inc., *A.I. Abdulagatov, R. Fitzpatrick, S.M. George,* University of Colorado, *B. Wu, T. Minton*, Montana State University

Polymers used on spacecraft are subjected to various threats including hyperthermal oxygen atoms, UV and VUV photons, and ions. These threats can degrade the polymer and lead to static charge accumulation. Nanometer thick inorganic films grown by atomic layer deposition (ALD) can protect polymers including Kapton, Teflon, and PMMA. We are developing multifunctional multilayer ALD films incorporating Al_2O_3 layers for preventing oxygen atom erosion, TiO_2 to minimize UV/VUV radiation damage, and ZnO to dissipate static charge. Such ALD-coated polymeric films are currently being tested in low Earth orbit on the International Space Station on MISSE-7b. In the laboratory, we are further exploring the mechanisms of polymer degradation by atomic oxygen and VUV radiation, as well as the cracking of inorganic films on polymers resulting from different thermal expansion coefficients. Field emission scanning electron microscopy images and profilometry measurements revealed that Kapton H samples coated with 25 ALD cycles (~3 nm) of Al_2O_3 completely resisted atomic oxygen erosion. Quartz crystal microbalance measurements of TiO_2 films deposited on PMMA substrates with an Al_2O_3 interfacial adhesion layer showed that 100 cycles (~6.2 nm) of TiO_2 resisted PMMA degradation upon VUV exposure. Mass losses of VUV-exposed PMMA samples coated with similar overall bilayer thicknesses but different Al_2O_3 thicknesses were compared to decouple the role of the overall Al_2O_3/TiO_2 bilayer coating acting as a physical barrier from the role of TiO_2 acting as a VUV filter.

TF-TuP20 Effects of Pulse Frequency on the Structural, Electrical and Optical Properties of Al-doped ZnO Films by Pulsed dc Magnetron Sputtering, ***C.T. Lee***, *B.H. Liou, W.H. Cho, C.N. Hsiao,* National Applied Research Laboratories, Taiwan, Republic of China, *K.S. Tang, C.C. Jaing*, Minghsin University of Science and Technology, Taiwan, Republic of China

The ZnO:Al (AZO) thin film was prepared on si and glass substrates at 200 ℃ by pulsed dc magnetron sputtering deposition. Effects of pulse frequency on the structural, electrical and optical properties of AZO films were investigated by field emission scanning electron microscopy, X-ray diffraction, Hall measurement and spectrometer. The columnar structures are observed by field emission scanning electron microscopy. X-ray diffraction analysis reveals that AZO films were polycrystalline and have preferred orientation along (002). The grain size and resistivity of AZO films were investigated as a function of pulse frequency (5-100 kHz). The maximum grain size and minimum sheet resistivity of AZO film with 20 kHz were 37.5 nm and 650 ohm/sqr, respectively. The average transmittance of AZO thin films was above 80% in the visible range. The presented results illustrate that the optimum properties of AZO films can be obtained at a pulsing frequency in the range of 5-100 kHz.

TF-TuP21 Fabrication of Cu-DLC Films by Cathodic arc Plasma Deposition, ***J. Yun***, National Chung Hsing University, Taiwan, *S. Han*, National Taichung Institute of Technology, Taiwan

Copper-doped diamond-like carbon (Cu-DLC) films with varying Cu concentrations were deposited on 7050 aluminum alloy substrates using cathodic vacuum arc (CVA) system. Acetylene reactive gases were also activated at a pressure of 20 mTorr to 30 mTorr and a temperature fixed at 180 °C to provide the DLC. Structure, interface, and chemical bonding state

of the investigated film were analyzed by transmission electron microscope (TEM), FTIR spectra, and X-ray photoelectron spectroscopy (XPS). The Cu-DLC film deposited exhibited an amorphous structure , while different fracture feature and surface morphologies was observed in these carbon films prepared under various acetylene reactive gases pressure. With increasing acetylene reactive gases pressure, the friction coefficient of the thin films is lower than 0.21 and the residual stress between the DLC thin films and aluminum alloy substrates can be substantially decreased after the effective doping of Cu into the films, which implies that the Cu-DLC films are suitable to be used as a protective coating on aluminum alloys.

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