Thin Films
Room Exhibit Hall C&D - Session TF-MoP
Aspects of Thin Films Poster Session

TF-MoP2 Effects of Annealing Gas on Characteristics of HfO@sub 2@ Deposited by ALD for MIM Capacitors, ***S.-W. Jeong***, *H.J. Lee, K.-S. Kim, M.-T. Yoo,* Sungkyunkwan University, Korea*; Y.-H. Roh,* Sungkyunkwan University, Korea, Republic of Korea*; T. Noguchi, J. Jung, W. Xianyu,* Samsung Advanced Institute of Technology, Korea

Research on the insulating films in metal-insulator-metal (MIM) capacitors has focused on ways to increase the dielectric constant of insulator to improve the packing density of integrated RF capacitors. High-k oxide (e.g., Ta@sub 2@O@sub 5@) has been suggested as an alternative material to replace SiO@sub 2@ and Si@sub 3@N@sub 4@. However, reliability problem caused by leakage current may limit the application of Ta@sub 2@O@sub 5@. Properties of HfO@sub 2@ grown on the Si substrate shows a dielectric constant which is comparable to that of Ta@sub 2@O@sub 5@. Further, the characteristics of HfO@sub 2@ more stable than those obtained from Ta@sub 2@O@sub 5@, suggesting that we may use HfO@sub 2@ film as insulator in MIM capacitor. In this work, we report the physical and electrical properties of ALD-deposited HfO@sub 2@ film (11-12 nm) annealed at various gases (N@sub 2@, O@sub 2@, N@sub 2@O). HfO@sub 2@ films were annealed at 400, 600, 800 °C using a rapid thermal processor for 1 min. Top and bottom metal electrodes were Pt and Pd, respectively. The electrical characterization indicates that HfO@sub 2@ MIM capacitors fabricated at 800 °C under O@sub 2@ ambient show the most desirable electrical properties, such as a high capacitance density of ~16.9 fF/µm@super 2@, a low leakage current of 2.7*10@super â?"4@ A/cm@super 2@ at -5 V, low-voltage coefficients of capacitance, and good-frequency dispersion properties. In addition, better properties were obtained from the samples annealed using N@sub 2@O than those of samples treated using N@sub 2@. These results indicate that oxygen content has certain role(s) on the electrical properties of ALD-deposited HfO@sub 2@ film. These results, as well as further investigation of physical properties of the samples using XPS, will be presented at the conference.

TF-MoP3 The Annealing Effect on the Diamond-Like Carbon Protective Antireflection Coating, ***W.S. Choi***, *K. Kim, J. Yi, B. Hong,* Sungkyunkwan University, Korea

Diamond-like carbon (DLC) film has many advantages like diamond film beside it has wide band gaps and its refractive index can be adjusted variably so the film can be utilized as protective coating for IR windows and anti-reflective coating for solar cells. In this study, DLC films were prepared by RF-PECVD (Plasma Enhanced Chemical Vapor Deposition) method on silicon substrates using methane (CH4) and hydrogen (H2) gas. We examined the effects of the post annealing temperature and the annealing ambient on tribological and optical properties of the DLC films. The films were annealed from 300 to 900oC in steps of 200oC by RTA equipment in different ambient. The thickness of the film was observed by a scanning electron microscope (SEM) and surface profiler. The structure and surface morphology of the films were examined using Raman spectroscopy, X-ray diffractometer and atomic force microscopy. The hardness and depth profile of the DLC film were measured with nano-indentor and Auger electron spectroscopy, respectively. The optical properties of DLC thin film were investigated by UV/VIS spectrometer, Fourier transform infrared spectroscopy (FT-IR) and ellipsometry. And also, we have checked their carrier life time.

TF-MoP5 Metalorganic Chemical Vapor Deposition and Characterization of Zr-silicate Gate Dielectrics, *J. Kim,* ***S. Lee***, *K. Yong,* POSTECH, Korea

Zirconium silicate [ZrSi@sub x@O@sub y@] film, demonstrating good thermal stability in direct contact with Si, is a very promising candidate to replace SiO@sub 2@ (k=3.9) gate dielectrics. Zr-silicate films were deposited by injecting tetrakis-diethylamido-zirconium [Zr(NEt@sub 2@)@sub 4@] and tetra-n-butyl-orthosilicate [Si(O@super n@Bu)@sub 4@] precursors all together into metal-organic chemical vapor deposition (MOCVD) reactor. The growth rate was about 1 nm/min at 450~500 @super o@C. High-resolution TEM image of Zr-silicate films showed an atomically flat interface of silicate/silicon even in ultra thin films and showed smooth surface with RMS (root mean square) value of 0.5 nm. The Zr/(Zr+Si) ratio was average 0.2 for the bulk film, indicating a Si-rich composition. However at the silicate/silicon interface, it shows a higher Zr concentration than Si, implying a Zr-rich composition at the interface. Zirconium silicate films with ~30 % ZrO@sub 2@ were amorphous up to 800 @super o@C and above 900 @super o@C, phase separation of the films occurred into ZrO@sub 2@ and Zr-silicate phases. Amorphous silicates are desirable in order to avoid dislocations and grain boundaries, which provide pathways for diffusion of dopants from the electrode to the substrate and may exhibit high leakage paths. ZrSi@sub x@O@sub y@ exhibited a leakage current density of 1.6 x 10@super -4@ A/cm@super 2@ at a gate bias of 1 V for an equivalent oxide thickness of 4.3 nm and showed very low hysteresis volatage (delta VFB) below 0.02 V, which indicates the low impurities and defect contents in Zr-silicate films.

TF-MoP6 Isotopically Concentrated Silicon Film Formation by Chemical Vapor Deposition, ***H. Yamamoto***, Japan Atomic Energy Research Institute, Japan*; H. Ohba,* Japan Atomic Energy Research Institute*; M. Sasase,* The Wakasa-wan Energy Research Center, Japan*; K. Yamaguchi, K. Shimura, S. Shamoto, A. Yokoyama, K. Hojou,* Japan Atomic Energy Research Institute

Isotopically concentrated silicon (@super 30@Si) film has been attempted to form by means of chemical vapor deposition. The natural isotope @super 30@Si can be transmuted into stable @super 31@P by the capture of a thermal neutron. If the @super 30@Si enriched layer is formed on the @super 28@Si or natural Si substrate, the enriched layer can act as "donor doping layer" by the transmutation. However, it is hard to obtain plenty of enriched @super 30@Si, since its natural abundance is only 3.1%. Recently, a method for highly efficient enrichment of @super 30@Si in a form of @super 30@SiF@sub 4@ has been established by Yokoyama et al.@footnote 1@ In the present study, the @super 30@Si enriched film (~several tens nm) was deposited on natural Si substrate by using RF plasma (13MHz, 300W) from gaseous mixture of SiF@sub 4@ and H@sub 2@ diluted with Ar. The optimum condition of Si deposition has been investigated by using natural SiF@sub 4@. Obtained film was characterized by X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD) and transmission electron microscopy (TEM). XPS results showed that an impurity phase appeared in the deposited film depending on the H@sub 2@/SiF@sub 4@ gas flow rate ratio and temperature during deposition. For example, the film contained ~10at.% of fluorine in the case of the gas ratio of 2~4 at 250°C. Even though the fluorine content decreased drastically with the increase of the gas ratio up to 10, it still remained at this temperature. The fluorine was not observed in the sample deposited at 400°C. Results of the other analyses will be also presented and discussed. @FootnoteText@ @footnote 1@A.Yokoyama, H.Ohba, et al., Appl.Phys.B 79 (2004) 883-889.

TF-MoP7 SiN Single Passivation Layer Grown by Linear Antenna Type Inductively-Coupled-Plasma Chemical Vapor Deposition for Top-Emitting Organic Light Emitting Diodes, ***H.-K. Kim***, *M.S. Kim, K.-S. Lee, S.H. Jeong, K. Kim,* Samsung SDI

Thin film single passivation layers (SiH@sub x@:H) for top-emitting organic light emitting diodes (TOLEDs) were deposited at substrate temperature of 40°C by using linear antenna type inductively-coupled-plasma chemical vapor deposition (ICP-CVD). It was found that the deposition rates were mainly determined by SiH@sub 4@ flow ratio at low temperature. Even at the low substrate temperature of 40°C, SiN@sub x@:H films showed a good moisture resistance and transparency of 10@super -5@g/m@super 2@/day and 92% respectively. In addition, current-voltage results showed that the SiN@sub x@:H deposition process produced negligible plasma damage, which was generally observed by plasma-related deposition processes.

TF-MoP8 Effect of Hydrogen Dilution on Microstructure of In Situ Polycrystalline Si Film Grown by Catalyzer Enhanced Chemical Vapor Deposition, ***M.S. Kim***, *H.-K. Kim,* Samsung SDI

The effect of hydrogen dilution on microstructure of in situ polycrystalline Si (poly-Si) films grown by catalyzer enhanced chemical vapor deposition (CECVD) has been investigated. It was shown that microstructure of the Si films grown at low substrate temperature (<300 °C) in CECVD was strongly affected by hydrogen dilution ratio (H@sub 2@/SiH@sub 4@). In addition, a secondary ion mass spectroscopy (SIMS) depth profile of the in situ poly-Si film grown by CECVD at SiH@sub 4@/H@sub 2@ (1/40 sccm) exhibited much lower hydrogen concentration than dehydrogenated amorphous Si film grown by conventional plasma enhanced chemical deposition (PECVD). These results indicated that the CECVD technique is a promising candidate to grow high quality in situ poly-Si films on glass or flexible substrate for low-temperature poly-Si (LTPS) and flexible displays.

TF-MoP9 Irradiation Effect of Nitrogen Ion Beam on Hydrogenated Amorphous Carbon Films, ***Y. Watanabe**, S. Katoh, N. Kitazawa,* National Defense Academy, Japan

Hydrogenated amorphous carbon (a-C:H) thin films were deposited on silicon single crystal substrates from toluene vapor using rf plasma at room temperature. After deposition, the a-C:H films were irradiated with a nitrogen ion beam and effects of nitrogen ion beam irradiation on surface morphology and composition were studied. Nitrogen ion irradiation was performed using a nitrogen ion beam of 0.2 to 1.5 keV for 10 min under the constant ion current density at room temperature. Surface morphology was observed by atomic force microscopy (AFM). Changes in composition and carbon-nitrogen bonding states were analyzed by X-ray photoelectron spectroscopy (XPS). Carbon structures were examined by Raman spectroscopy. AFM observations revealed that the film surface became smooth after nitrogen ion beam irradiation and notable difference in surface smoothing is hardly observed between 0.2 and 1.5 keV ion irradiation. XPS studies showed that nitrogen was absorbed near the surface of the a-C:H films after nitrogen ion irradiation and combined with carbon, resulting in carbon nitride formation. Depth profiles obtained by XPS showed that 1.5 keV nitrogen ion irradiation is more effective for carbon nitride formation than 0.2 keV ion irradiation. Carbon structures did not change remarkably after nitrogen ion irradiation. These results show that irradiated nitrogen ions are absorbed into the a-C:H films to form carbon nitride layers near the surface. The effect of the nitrogen ion energy on surface morphology and nitrogen implantation will be discussed.

TF-MoP10 Fabrication of Micropatterned Mesoporpous Silica Films on a Flexible Polymer Substrate Through a Pattern Transfer and Subsequent Photocalcination, ***A. Hozumi**, M. Inagaki, Y. Yokogawa, T. Kizuki,* AIST, Japan*; N. Shirahata,* NIMS, Japan

Mesoporous silica (MPS) have attracted much attention due to their advanced applications. In order to fabricate microdevices from such nanoporous materials, they must be formed into microstructured thin films on certain substrates. In particular, such microfabrication on polymeric surfaces has been attracting more and more attention to fabricate flexible microdevices. In this study, we report a novel way to fabricate MPS microstructures on the flexible polymer substrate based on a pattern transfer method. First, fluoroalkylsilane (FAS) self-assembled monolayer (SAM)-covered Si substrate was photolithographically micropatterned. Next, the second SAM, e.g., aminosilane (AEAMPS) SAM was site-selectively formed onto lithographically defined patterns through a liquid phase process. The substrate was then immersed in a solution consisting of tetraethoxysilane, cetyltrimethylammonium chroride, hydrochloric acid and water. As evidenced by AFM, surfactant-silica composite film was preferentially deposited on the FAS-SAM regions, while undesirable deposition was not observed on the AEAMPS-SAM regions. In order to transfer the micropatterns to the polymer substrate, they were attached firmly to the polymer surface. Subsequently, the polymer substrate was heated to its glass transition point and was kept at this temperature for 1 hour under the pressure of 2~4 MPa. AFM, EDS and XRD confirmed that the micropatterns were successfully transfered to the polymer substrate without distortion their morphologies and nanostructures, since the adhesion of the micropatterns and the FAS-SAM surface was very weak. Finally, on the basis of photocalcinationt, the micropatterns were exposed to172 nm vacuum UV light for 3 hours at 10 Pa to eliminate surfactant molecules in order to obtain nanopores. The resulting MPS micropatterns adhered very tightly to the polymer substrate and never peeled off even after a tape peeling test.

TF-MoP11 XPS and FTIR Characterization of C60 States in C60 Doped Conducting Polymers, ***H. Kato**, S. Takemura, K. Iwasaki, N. Nanba, T. Hiramatsu,* Kanto Gakuin University, Japan*; O. Nishikawa, M. Taniguchi,* Kanazawa Institute of Technology, Japan

Conducting polymer polythiophene (PT) film incorporated with C60, highly functional molecule, was prepared by electrochemical doping and diffuse injection methods. Charge transfer and interaction between the doped dye molecule and PT polymer chains were investigated by XPS analysis of the core-level energies and spectral profiles of the atomic components. Vibration states of the doped dye molecule and the polymer backbone were also investigated by FTIR RAS and FTIR transmission in order to examine the dopant-chain interaction in the hybrid films. The XPS spectral profile of the electrochemical doping sample was different from that of the casting sample, which reflects the different dopant-chain interaction in polymer films. It is known that C60 is a highly symmetrical molecule with HOMO fivefold (hu) and LUMO threefold (t1u) enables various valence values to be possible filling the degenerate LUMO levels with different number of electrons. The higher binding energy peaks of C 1s reflect the valence values of C60. FTIR transmission measurement clarified that C60 molecules were doped in the polymer film by both methods of electrochemical doping and casting because characteristic peaks due to the vibrational modes of C60 were observed. The C60 originated peaks were also observed in the FTIR RAS spectra. The peaks due to C60 were differently observed in the spectra of electrochemical doping and casting samples reflects the different doping states of C60. The results of XPS and FTIR suggests the controllability of conductive state of PT by changing dopant valence values by electrochemical doping methods. XPS core-level analysis of S 2p was composed of several peak components. The energy position of the main peak is almost positioned in the reference value. The lower energy and the higher energy components reflect the charge transfer between polymer chain and C60 molecule. The present work supported by "High-Tech Research Center" Project aided by MEXT.

TF-MoP12 XPS Characterization of Electrochemical Growth of Conducting Polymer on Oxidized Si Surface, *H. Kato, **S. Takemura**, N. Takakuwa, K. Ninomiya, T. Watanabe, N. Nanba, T. Hiramatsu,* Kanto Gakuin University, Japan

Electrochemical growth of conducting polymer polythiophene (PT) film on oxidized Si wafer was closely investigated by XPS. Initial stage of polymer growth was investigated by analyzing the core-level energies and spectral profiles of the atomic components. Oxidized Si surface was also closely characterized by XPS by using curve-fitting of Si 2p and Si 2s core-level spectra to determine precisely the Si covalent states of surface layers. The purpose of the present work is to clarify the interface between an organic upperlayer and oxidized Si sublayer which is an interesting issue from practical point of view in wet fabrication techniques. The XPS spectrum of Si 2p and Si 2s of the oxidized substrate surface was composed by 5 peaks which correspond with Si valence values, such as Si, Si+, Si2+, Si3+, SiO2. The core-level energy positions of those different states were determined by XPS. The Si wafer was prepared through several stages of cleaning process. The surface roughness was reduced and the STM image of nano-scale orederd surface was obtained although the surface layers were oxidized investigated by FTIR RAS and XPS measurements. Electrochemical PT growth at initial stage was implemented on the oxidized Si substrate. Obtained XPS spectra of Si 2p and 2s showed that the Si+ peak grew associated with polymer deposition. This experimental fact reflects the interface linkage between organic polymer chain and Si oxidized layer. The bonding between organic and inorganic species will be also discussed. The present work supported by "High-Tech Research Center"Project aided by MEXT.

TF-MoP13 Controlled Synthesis and Magnetic Properties of Iron Oxide Particles Formed by Thermal Decomposition of Rapidly Expanded Supercritical Solutions, *S. De Dea, D. Graziani, **D.R. Miller**, R.E. Continetti,* University of California, San Diego

Films of iron oxide fine magnetic particles were synthesized by rapidly expanding a supercritical solution (RESS) of ferric acetylacetonate (FeAA) and CO@sub 2@ onto a hot silicon wafer. The temperature of the substrate was set at a value such that thermal decomposition of the solute would occur at the silicon surface with subsequent formation of iron oxide particles in an oxidizing atmosphere. We present the details of the RESS apparatus and initial data on the FeAA/CO@sub 2@ system and the deposited thin films. In the RESS process particle morphology and composition can be controlled by adjusting process parameters such as pre-expansion temperature, pressure and composition of initial solution, temperature of the substrate, nozzle to substrate distance, and expansion chamber pressure and composition. In the process design and utilization of RESS it is very important to acquire accurate solubility data and then to monitor the composition of the expanding solution. For this purpose a spectroscopic view cell was introduced in the RESS system, prior to the expansion, to allow both equilibrium solubility as well as on-line concentration measurements. Obtained solubility data will be presented and compared with predicted solubility from the Peng-Robinson equation of state. The deposited particles were analyzed with SEM, XRD, EDX and a SQUID based magnetometer. It was found that smaller nanoparticles were formed when the RESS expansion was into the vacuum. The effect of the supersonic expansion jet structure on particle morphology will be discussed. EDX and XRD showed that complete decomposition of FeAA occurred at the silicon surface and that the particles consisted of a mixture of crystalline Fe@sub 2@O@sub3@ and Fe@sub 3@O@sub 4@. Magnetization measurements were performed at different temperatures and they showed that the particles have ferromagnetic properties. Results

for the coercive field as well as saturated and remanent magnetization will be presented.

TF-MoP14 Growth of Novel NaCdF@sub3@ Thin Films by Pulsed Laser Deposition for Advanced Ferroelectric Applications, ***T. Aburada***, *C.T. Nelson,* University of Virginia*; R.W. Smith,* University of Nebraska-Omaha*; S.B. Qadri,* US Naval Research Laboratory*; J.M. Fitz-Gerald,* University of Virginia

Ferroelectrics are an important class of materials in a variety of applications including, non-volatile random access memories.@footnote 1@ Recent computer simulations have predicted that NaCdF@sub 3@ has a ferroelectric ground state.@footnote 2@ Moreover, NaCdF@sub 3@ is predicted to have a large energy band gap and be transparent in the UV spectrum, thus having potential for use in electro-optic applications.@footnote 2@ Thin films of NaCdF@sub 3@ were grown by Pulsed Laser Deposition (PLD) on Si (100) substrates using a high purity NaF and CdF@sub 2@, 1:1 molar fraction, starting target in a high vacuum chamber. A KrF excimer laser (@lambda@ = 248 nm) was used to deposit films as a function of growth temperature, system pressure, and laser energy. All films exhibited a large degree of roughness along with pronounced surface irregularities, as evidenced by Scanning Electron Microscopy (SEM) images. X-ray Diffraction (XRD) data showed that the films consist of two binary phases: CdF@sub 2@ and NaF, closely matching the stoichimetries of the starting target constituents. Although XRD analysis indicates the absence of the ternary NaCdF@sub 3@ phase, it is important to point out that oxide peaks are not observed. This is a significant hurdle to overcome in producing these materials. Compositional measurements by Energy Dispersive X-ray Spectroscopy (EDXS) indicate that the atomic fraction of Na to Cd is lower in the deposited thin film than in the initial target material. A comparison of the XRD spectra of the deposited film and the target reveals a decrease in the NaF phase in the films. With the large band gap associated with NaF, KrF irradiation is not the optimum choice due to its relatively low energy of 5eV. @FootnoteText@ @footnote 1@J.S. Horwitz, K.S. Grabowski, D.B. Chrisey, R.E. Leuchtner, Appl. Phys. Lett. 59 (13), 23 (1991)@footnote 2@ C. Duan, W.N. Mei, J. Liu, W. Yin, J. R. Hardy, R.W. Smith, M.J. Mehl, L.L. Boyer, Phys. Rev. B 69, 033102 (2004).

TF-MoP15 Low Temperature Formation of High-Quality SiO@sub 2@ Thin Film using UV Light-Excited Ozone, ***A. Tosaka***, National Institute of Advanced Industrial Science and Technology, Japan*; T. Nishiguchi,* Meidensha Corporation, Japan*; H. Nonaka, S. Ichimura,* National Institute of Advanced Industrial Science and Technology, Japan

Fabrication of high quality SiO@sub 2@ film at low temperature is required for a gate dielectric film in thin film transistor for future display devices. We have developed an oxidation system using highly concentrated ozone excited by KrF laser light (248 nm) since it is expected that ozone molecules exposed to 248 nm light readily decompose into excited oxygen atoms, O(@super 1@D), and oxygen molecules. It was revealed that the UV excited ozone results in SiO2 film growth more than 3.6 nm thickness at 70 ˚C within 10 min., sufficiently thick as a barrier oxide. The growth rate behavior shows that there are two oxidation mechanisms and the activation energy is almost zero (0 to 5 min.) and 0.14 eV (after 5 min.), respectively. The low activation energy is due to the reaction between highly-reactive O(@super 1@D) and the silicon surface layers whose electric state is UV-excited. The current density (J)-electrostatic field (E) characteristics of the SiO@sub 2@ film show the ideal tunneling current properties, indicating that the KrF laser light irradiation does not induce defects in the film. Details reaction mechanism of O(@super 1@D) with silicon in terms of the density of excited oxygen atoms will be also discussed.

TF-MoP16 Influences of the Dopant Concentration and Thermal Treatment on Optical and Electrical Properties of C-oriented Aluminum-Doped Zinc Oxide Films, *S.-Y. Kuo,* National Applied Research Laboratories, Taiwan*;* ***W.-C. Chen***, National Taiwan Normal University, Taiwan*; C.Y. Su,* National Applied Research Laboratories, Taiwan*; C.-P. Cheng,* National Taiwan Normal University, Taiwan

Transparent and conductive Al-doped zinc oxide (ZnO:Al, AZO) thin films with highly preferential c-axis orientation have been prepared by the sol-gel technique. Structural, electrical and optical properties were performed by XRD, AFM, SEM, four-point probe, photoluminescence (PL) and UV-VIS transmission measurements. The influence of dopant concentration and thermal treatment on the microstructure as well as on the electrical and optical properties of the thin films is investigated. It was found that the FWHM of XRD patterns reach a minimum at annealing temperature of 750 @super o@C, which is consistent with the results of SEM images. Room-temperature PL spectra show two main peaks centered at about 380 nm (UV) and 520 nm (green). The variation of UV-to-green band emission was greatly influenced by annealing temperatures. The minimum sheet resistance of 10@super 5@ @ohm@/sq. was obtained for the film doped with 2 wt.% Al, annealed at 650 @super o@C. Meanwhile, all AZO films are very transparent, between 85 and 95 % transmittance, within the visible wavelength region. The optical absorption edge was found to blueshift with increasing doping concentration as well. Possible causes to the above will be given and discussed. These results indicate that AZO thin films might be a promising candidate for future photonic applications.

TF-MoP18 Electrical, Optical and Structural Properties of Arsenic-doped (Zn,Mg)O Films, ***J.-M. Erie***, *Y.J. Li, H. Kim, K Ip, S.J. Pearton, V. Cracium, D.P. Norton, J. Chen, F. Ren, I. Kravchenko,* University of Florida

Zinc oxide is an attractive compound semiconductor for transparent electronics, UV light emitting diodes (LEDs) and laser diodes (LDs). It possesses a direct band gap of 3.37eV, a large exciton binding energy of 60 meV and a high theoretical saturation velocity. However, the formation of p-type material with a high hole carrier density remains a major challenge. Recent efforts have focused on ZnO p-type doping with group V anions, namely N, P or As. In this work, the synthesis and properties of As-doped (Zn,Mg)O thin films grown by pulsed laser deposition are reported. Epitaxial (Zn,Mg)O films doped with 0.02-0.2 at % As are grown using a single ablation target synthesized with high-purity zinc arsenide as the source of arsenic. The structure and phase formation are characterized as a function of growth temperature and oxidation conditions. Both oxygen and ozone are explored as oxygen source gases. Film properties are characterized using Hall measurement, photoluminescence, scanning electron microscope, and X-ray diffraction. This work was supported by the National Science Foundation, Air Force Office of Scientific Research, the Department of Energy, and the Army Research Office. The authors would also like to acknowledge the Major Analytical Instrumentation Center, Dept. of Materials Science and Engineering, University of Florida.

TF-MoP19 Fe(001) Thin Films for Novel Applications, ***C.A. Meserole***, *G.L. Fisher, D.J. Hilton, R.D. Averitt, D.J. Funk, A.J. Taylor,* Los Alamos National Laboratory

The electrical and magnetic properties of thin iron (Fe) films have sparked significant scientific interest. Our interests are two-fold. First, Fe(001) films are ideal targets for a newly developed ultrafast x-ray diffraction instrument designed to understand complex behavior, such as melting or solid-solid phase transitions, in shock-loaded materials. The instrument utilizes an intense laser pulse to initiate a shock wave in the sample and x-ray diffraction to study the material's response. This target/instrument combination will allow for directly comparing experimental data to published molecular dynamics simulations of a shock wave propagating along the [001] direction in an Fe crystal. Second, we have discovered a novel application for thin Fe films, which generate picosecond, broadband terahertz frequencies after intense femtosecond pulse excitation by a Titanium:Sapphire laser. The terahertz emission provides a direct measure of the induced ultrafast magnetization change. Film thickness not withstanding, the criteria for samples used in both experiments are identical due to the similarities of the experiments. For example, the substrate must permit the epitaxial growth of continuous single/monocrystalline films, yet must be transparent to a pump laser. Fe(001) films grown on MgO(001) substrates make ideal samples for both experiments. Issues such as generating a specific crystallographic orientation in the Fe film, film growth mode, substrate preparation and surface contamination, are discussed, along with an overview of the applications for these films.

TF-MoP20 Electron Cyclotron Resonance Remote Plasma Enhanced Atomic Layer Deposition of Ruthenium Thin Films, *E.-J. Lee, B.-Y. Kim, S.K. Park, H.-D. Kim, J.-W. Park,* ***M.-G. Ko***, Hanyang University, South Korea

As the silicon process migrates to small device geometries, new deposition process technology will be required to solve the problems obtained with high trench capacitor and ultra thin gate oxide. Attempts to deposit material with atomic level control, atomic layer deposition as a technique which can be available good film uniformity and excellent step coverage have been reported. Ruthenium is a noble metal has low electrical resistivity, high chemical inertness, thermal stability and hardness. Especially, ALD of ruthenium thin films using the metal electrode for trench DRAM capacitor have been researched because the films have not only excellent uniformity also high work function energy of deposited films. In this study, ruthenium thin films prepared by high density plasma ALD with

Ru(EtCp)@sub2@ as ruthenium precursor and NH@sub3@ gas as plasma ion source from room temperature to 400°C. ECR remote plasma as high density plasma ion source has over 10@super12@ /cm @super3@ ion density, therefore, ligands of precursor gas can be removed easily. Ruthenium thin films was grown to self-limited reaction process to be ranged from 250°C to 290°C deposited by conventional ALD on 44 nm thick TiN/ 4 nm thick Ti / 100 nm thick SiO@sub2@ / p-type (100) Si wafer. This result reveals that ALD process depends on chemical limited reaction with surface atom and precursor gas, furthermore, this temperature region possess sufficient energy to adsorb ruthenium precursor gas on substrate. Conventional ALD of ruthenium thin film deposited with oxygen and argon mixed gas as a reaction gas is formed ruthenium and ruthenium oxide, however, high-density remote plasma enhanced ALD of ruthenium deposited using NH@sub3@ as a plasma gas is formed only ruthenium films by low angle HRXRD (High Resolution X-ray Diffraction) peaks. Ruthenium thin films deposited by HDPALD have surface morphology of 10 ~ 12 Å, and electrical resistivity of 11 ~ 15 µm cm.

TF-MoP22 Experimental AES and Computer Model Based Elemental Depth-Profile Analysis of Tungsten Carbide Doped Diamond Like Carbon Films, ***J.A. Carlson***, *J. Abou-Hanna, J. Lozano,* Bradley University

Tungsten-doped diamond-like carbon (DLC) coatings, with a thickness of approximately three microns, have been magnetron sputtered onto 52100 steel with chromium and chromium/tungsten carbide dual interlayers using a Hauzer Techno Coating HTC 1200 4 UBM system. The process gas for the deposition is acetylene. The deposition chamber uses a two degree of freedom rotational system to rotate parts to be coated so that eventually each portion of the part will experience the full impact of the target. Depending on the speed of the rotation, the rotation pattern may take several minutes to repeat. At certain intervals during deposition, the acetylene flow is linearly altered to change characteristics throughout the film. AES sputter depth profiling analysis shows a spatial dependency on the depth profile which is likely attributable to the fixture rotational system. AES depth profiling also reveals trace amounts of titanium within the DLC and within the interlayers. The presence of titanium has further been confirmed with EDS/SEM analysis. Furthermore, AES shows significant amounts of oxygen in the area of the interlayer/substrate interface. Lastly, in addition to the experimental data, mathematical models are presented that were used to predict film chemistry, film thickness, and film structure.

TF-MoP23 Improvement of Surface Roughness in Indium Tin Oxide (ITO) Anode for Organic Light-Emitting Diode (OLED) by Water Vapor Injected Radio Frequency Sputtering, ***K.-S. Lee***, *D.-G. Kim, H.-K. Kim,* Samsung SDI

We report on improvement of surface roughness in indium tin oxide (ITO) anode which was grown by water vapor injected rf sputtering method, for use in organic light-emitting diode (OLEDs). It is shown that ITO films prepared by water vapor injected rf sputtering have very smooth surface (Rms 20.Å, PtV 174Å), low resistivity (0.00019 Ω/square), and high transmittance (~ 96%). Scanning electron microscopy (SEM), atomic force microscopy (AFM), and x-ray diffraction (XRD) examination results show that film surfaces of ITO were mainly influenced by the preferred orientations in ITO anode films. In addition, secondary ion mass spectroscopy (SIMS) result clearly shows that OH content in ITO film was increased by water vapor injection. OLED with ITO cathode prepared by water vapor rf sputter method show lower turn on voltage as compared to that of OLED with ITO films prepared by rf sputtering without water vapor. Based on SEM, AFM, and XRD results, we describe a possible mechanism to explain improved electrical and surface properties of ITO films prepared by water vapor injected rf sputtering.

TF-MoP24 Characteristics of Indium Zinc Oxide Top Cathode Layer Prepared by Box Cathode Sputtering for Top-Emitting Organic Light-Emitting Diodes, *H.-K. Kim,* ***D.-G. Kim***, *K.-S. Lee,* Samsung SDI

We report on plasma damage-free deposition of indium zinc oxide (IZO) cathode layers for top-emitting organic light-emitting diodes (TOLEDs) by using a box cathode sputtering (BCS) technique. A sheet resistance of 42.6W/Â£ and average transmittance above 88% in visible range were obtained even in IZO layers deposited by the BCS at room temperature. The TOLED with IZO top cathode layer grown by the BCS shows electrical characteristics comparable to TOLED with only thermally evaporated Mg-Ag cathode. In particular, it is shown that the TOLED with the IZO top cathode layer deposited by the BCS has very low leakage current density of 1X10@super -5@mA/cm@super 2@ at reverse bias of -6V. This suggested that there is no plasma damage caused by the bombardment of energetic particles during IZO sputtering process. Based on current-voltage, x-ray diffraction (XRD), high-resolution electron microscopy (HREM), scanning electron microscopy (SEM), and atomic force microscopy (AFM) examination results, possible mechanisms to explain plasma damage-free sputtering of the BCS system are suggested.

TF-MoP26 Fabrication of Long Lengths of Flexible High Temperature Superconductor Thin Film Tapes for Electric Power Applications, ***V. Selvamanickam***, *Y. Chen, X. Xiong, Y. Li, Y. Xie, Y. Qiao, J. Reeves, P. Hou, M. Gardner, T. Salagaj, K. Lenseth,* SuperPower

High Temperature Superconductors (HTS) have immense potential in electric power applications such as cables, motors, generators, and transformers. The zero-resistance property of HTS can be beneficially used to transmit up to 10 times more power in cables, and reduce the size and weight of rotating machinery and transformers by half. SuperPower is scaling up the so-called second-generation HTS conductors which are based on thin film tapes of epitaxially grown superconducting films. Flexible metal substrates such as Hastelloy are used and highly biaxially-textured oxide buffer templates are deposited by ion beam assisted deposition and magnetron sputtering. The buffer layers are comprised of a multilayer stack of oxides, each layer comprising of about 10 to 100 nm. Y-Ba-Cu-O superconducting films are then deposited on the buffer stack in thickness of 1 to few microns by metal organic chemical vapor deposition (MOCVD). Overlayers of silver and copper films are used to complete the conductor. SuperPower has established Pilot-scale facilities for producing long lengths of high-performance second-generation HTS thin film tape conductors. We have scaled up the processes to 100 m lengths with critical currents exceeding 100 A at 77 K. In this presentation, we will discuss the recent advances in scale up several thin film process technologies, associated equipment and process control techniques to fabricate second-generation HTS thin film tapes for electric power applications. Prototype electric power devices fabricated with these HTS thin film conductors will also be presented.

TF-MoP27 Flexible Gas Barrier Coatings Based on Roll-to-Roll Symmetric Magnetron Sputtering, ***C.-S. Wang***, *K. Sasaki,* Kanazawa University, Japan*; S.-F. Chen,* National Taipei University of Technology, Taiwan*; T. Hata,* Japan Science and Technology Agency

Superior gas and water vapor barrier coatings on polyethylene terephthalate substrate were prepared by roll to roll symmetric magnetron sputter technique. It has considerable attention that electronic devices such as flat panel displays, electronic paper and solar cell are to be flexible. In general, replacing the substrate from glass to plastic film, the gas permeability is so high that the oxygen and water vapor through the film damage the device. In this work, a new roll-to-roll coater for 300 mm web width combined with asymmetric magnetron sputtering has been developed to produce flexible gas barrier coating with high productivity. Three pairs of symmetric magnetron sputtering cathodes were sited on the both side of the substrate to realize subsequent coating of different layers and low-temperature deposition. On the other hand, the gas barrier coatings composed of 4 layered silicon oxynitride and oxide anti-reflection coatings have been investigated to improve resistance of the oxygen and moisture permeability. As experiments, the gas barrier properties were strongly depended on the film density and thickness and indicated that the gas barrier properties of 4 layered coatings were superior to single layer. The results show the transmission rate of water vapor bellow 0.07 cc/m@super 2@-day-atm and the oxygen transmission rates as low as 0.2 cc/m@super 2@-day-atm, moreover, an average transmittance rate of 98% in the range of visible spectrum has been measured. These competitive values of the coating can be actualized a high throughput of up to 1 m/min at economic coating cost.

TF-MoP28 Sputtering of Y3Al5O12:Cr Thin Films for Temperature Sensor Applications, ***Y. Deng***, *P.D. Rack,* University of Tennessee

Phosphor materials can be used as a temperature sensor by monitoring the phosphor decay time. Chromium-doped yttrium aluminum garnet (Y3Al5O12:Cr, or YAG:Cr) powders have been used in phosphor thermometry as its decay time has been well calibrated from room temperature to 600 Celsius. While powder paints are useful in some applications, these paints can flake and peel under some harsher environments. To ameliorate this problem, we are exploring the properties of YAG:Cr thin films. In this work, YAG:Cr thin films were sputter deposited in a combinatorial fashion to rapidly determine the optimum chromium concentration. The photoluminescence (PL) properties were correlated to the chromium concentration and an optimum concentration of 0.7 atomic percent was determined. Subsequently, a design of experiments was conducted to study the effects that the substrate temperature, substrate bias, and oxygen flow rate have on the YAG:Cr thin film PL and crystallinity.

An optimum sputtering condition was found. Finally, temperature dependent PL intensity was measured as a function of temperature to understand the thermal quenching phenomenon.

TF-MoP29 Film Properties of Transparent Conductive Oxide Films Deposited from Either ZnO- In@sub2@O@sub 3@or ZnO-SnO@sub2@ Systems with Additional Ga@sub2@O@sub3@ Impurities, ***K. Tominaga,*** *D. Takada, Y. Sukeda, Y. Nishimura, T. Moriga, I. Nakabayashi,* Tokushima University, Japan

Recently transparent conductive oxide films with smooth surface are expected. Lower deposition temperature is also expected for the TCO in polycarbonate substrate. For these applications, amorphous transparent conductive films are expected to be one of adequate materials. Amorphous films can be deposited in the system of ZnO-In@sub 2@O@sub 3@, or ZnO-SnO@sub 2@. Therefore we deposited those films, and investigated the influence of the incorporation of Ga@sub 2@O@sub 3@ on the film properties for those systems. Transparent conductive oxide films deposited from either ZnO-In@sub 2@O@sub 3@ or ZnO-SnO@sub2@ systems with additional Ga@sub2@O@sub3@ impurities were deposited by facing target sputtering system. ZnO:Ga and In@sub2@O@sub3@ targets were used for ZnO-In @sub2@O@sub 3@ films, and ZnO:Ga and In@sub2@O@sub3@ for ZnO-SnO@sub 2@ films. Two targets were sputtered simultaneously in Ar gas at 1 mTorr, and electric current ratio @deruta@=I@sub Zn@/(I@sub Zn@+I@sub In@) or I@sub Zn@/(I@sub Zn@+I@sub Sn@) was adopted as a deposition parameter to change film composition. Discharge current of each target was changed from 0 to 80 mA in order to change the content ratio of Zn/(In+Zn) or Zn/(Sn +Zn) in the film. Compositional ratios in films were estimated by X-ray fluorescence analysis. We could deposit ZnO-In@sub 2@O@sub 3@ amorphous films between Zn/(Zn+In)=0.2-0.5 even at a temperature of 250 Â°C. Low resistivity of the order of 10@super -4@@ohm@cm was attained in amorphous phase. Optical transparency was good for all films. For the amorphous films, optical bandgap energy shifted to higher energy side with decreasing the resistivity. Homologous films were deposited between Zn/(Zn+In)=0.5-0.75. These films had higher resistivity and larger optical bandgap than those of amorphous films. Similar results were obtained for SnO@sub 2@:Sb and ZnO:Ga, although the film resistivities were higher than ZnO-In @sub2@O@sub 3@.

TF-MoP31 Palladium Oxide Composite Films Containing Palladium Metal Phase Fabricated by Reactive Ion Beam Sputter-Deposition, ***T. Ichinohe,*** *S. Masaki,* Tokyo National College of Technology, Japan*; K. Kawasaki,* TDY Co., Ltd., Japan

Palladium oxide (PdO) is known to be p-type semiconductor with 1.5-2.2 eV band gap, and generally formed by thermal oxidation over 400@super o@C. This study reports the relation between formation of PdO and the parameters of reactive ion beam sputter-deposition, such as various substrate temperatures, deposition rates, and oxygen flow rates. According to X-ray diffraction (XRD) study, PdO(002) mixed with Pd(100) was formed in the films at low substrate temperature (T@sub sub@). When T@sub sub@ was 200@super o@C, the XRD intensity of PdO(002) seemed to become higher than Pd(100), in other words, it was tended to show the ratio of their peak intensities (I@sub PdO@/I@sub Pd@) higher than 1 indicating that the formation of PdO was relatively dominant than that of Pd at T@sub sub@=200@super o@C. The intensity of PdO(002) decreased or sometime disappeared when the films were formed at T@sub sub@=400@super o@C. The optimal parameters of reactive ion beam sputter-deposition can lead to form palladium oxide films at low temperature.

TF-MoP32 Growth and Properties of CdTeO@sub x@ Films by Reactive rf Magnetron Sputtering: CdTeO@sub 3@ a High-quality Transparent Material for Solar Cell Applications, *S. Jiménez-Sandoval,* Centro de Investigación y de Estudios Avanzados del IPN, Mexico*;* ***J. Carmona-Rodríguez,*** *R. Lozada-Morales,* Benemérita Universidad Autónoma de Puebla, Mexico*; O. Jiménez-Sandoval, M. Meléndez-Lira, C.I. Zúniga-Romero,* Centro de Investigación y de Estudios Avanzados del IPN, Mexico

CdS/CdTe heterostrtuctures is one of the leading solar cell technologies nowadays. One of the current approaches is the use of thin (~ 100 nm thick) CdS layers to improve cell efficiency. However, as the thickness of the CdS layer is reduced there is a greater chance for the appearance of micro junctions between the p-type CdTe layer and the transparent conducting oxide used as front contact, reducing cell efficiencies. It has been recently suggested that the use of a highly resistive buffer layer could avoid micro shunt formation. In order to gain further insight on the formation of transparent CdTe-based materials, we report on the properties of CdTeO@sub x@ films grown by reactive rf sputtering and of films annealed after deposition. The films were grown under an argon flow of 12 sccm and using oxygen flows of 0, 3, 5, 7, 8, 9, 9.5, 10, 10.5 and 11 sccm. This range of oxygen flows was equivalent to oxygen partial pressures within the chamber from 6.7 x 10@super -5@ (3 sccm) to 1.1x10@super -4@ Torr (11 sccm). The substrate temperature was maintained at 400°C for all growths with deposition times of 35 minutes at 35 W of power applied to the 99.999% pure CdTe target. The X-ray diffraction results indicate that the structure of the films was a mixture of cubic/hexagonal phases, typical of CdTe films, for films grown with oxygen flows of up to 10.5 sccm. This structure, however, is no longer sustained when the oxygen flow reaches 11 sccm. At this point, the X-ray diffraction peaks narrow because the material reaches the stoichioimetry and structure of high-quality CdTeO@sub 3@. Accordingly, the bandgap increases from 1.50 to 1.67 eV as the oxygen flow increases from 3 to 10.5 sccm, and at 11 sccm the band gap jumps to 3.73 eV, becoming a transparent, highly resistive film. Annealing the films for two hours under an inert atmosphere at 450°C does not produce significant changes in the crystalline structure, optical properties or bandgap values.

TF-MoP34 Electron Beam Induced Processing of Nanoscale Features: Process Parameters, Simulated Growth, and Nanoscale Applications, ***P.D. Rack,*** *University of Tennessee; J.D. Fowlkes,* University of Tennessee, US*; S.J. Randolph,* University of Tennessee

The rapid and precise direct write growth of nanoscale features by electron beam induced deposition (EBID) requires the optimization of growth velocity while maintaining nanoscale feature dimensions. There is a vast and complex EBID parameter space includes the precursor gas pressure, the primary electron beam energy, the electron beam current, surface diffusion rates of adsorbed precursor species, thermal effects on desorption, and the cascade of electron species produced by inelastic scattering processes. These variables affect the probability of precursor dissociation and hence determine the feature growth velocity and the size of the structure through a series of complex, coupled nonlinear interactions. A dynamic computer simulation based on Monte Carlo calculation sequences was created to aide in the interpretation of experimental observations by simulating experimental growth conditions. In this presentation, we will describe the parameter space and illustrate some of the complex interactions and introduce a Monte Carlo growth simulation. Experimental observations will be correlated to the simulated results. Finally, several nanoscale devices grown with electron beam induced processing will be demonstrated.

TF-MoP35 Influence of Sputtering target Structure on the Deposited Film Properties, ***C.F. Lo,*** *Praxair Surface Technologies - MRC*

This study correlated sputtering targets and deposited film properties in physical vapor deposition (PVD). When the sputtering targets consist of multiple elements, in addition to sputtering parameters, distribution of the individual elements or the constitutional target structure will affect the deposited film properties. In this report, we investigated the influences of target structures, including inter-diffusion between W and Ti in W-10 wt% Ti, precipitate size of Si in Al-1 wt% Si and distribution of Al10Mo inter-metallic phase in Al-2 at% Mo, on the deposited film properties. The results indicated that the greater extent of inter-diffusion between W and Ti of the W-10 wt% Ti target, the higher the compressive stress of the deposited film. The larger the Si precipitates in the Al-1 wt% Si target, the larger the Si precipitates in the deposited film. The larger the Al10Mo inter-metallic phases in the Al- 2 at% Mo, the less but larger whiskers generated on the annealed films. These evidences suggest that, although the films are formed by re-arrangement of the bombarded atoms from the sputtered target, mirror effect from target to film exists via PVD.

TF-MoP36 Reactive Pulsed DC Magnetron Sputtering of Oxide Films, ***M. Ye,*** *Applied Materials, Inc.*

Reactive pulsed DC magnetron sputtering extends the capabilities of DC sputtering to the area of insulating thin films deposition. The occurrence of arcing can be avoided and the plasma can be stabilized by periodically discharging the poisoned regions of the target through target voltage reversals. By careful design of hardware and selection of appropriate operating conditions, successful processing of various oxide films (aluminum oxide, tantalum oxide, and titanium oxide, etc.) on Applied Materials 200mm Endura platform is demonstrated in this paper. The experimentally established hysteresis curves are compared with modeling analysis. Film characterization results, including deposition rate, film stress, composition, optical index of refraction, density, and roughness, are presented. The effects of oxygen flow rate are studied. It is shown that

amorphous films with low stress level, good adhesion, smooth surface and the right stoichiometry can be achieved. Oxide films have been used in a variety of applications, including semiconductor devices, optical films, and MEMS devices. Compared to other deposition methods, DC magnetron reactive sputtering proves to be a simple yet powerful and efficient way of depositing insulating thin films, in both manufacturing environment and R&D applications.

TF-MoP37 Synthesis and Characterization of SiN@sub x@ Films Deposited on Silicon by Reactive RF Sputtering@super *@, ***C. Mendoza-Barrera**, E. Valaguez,* UPIITA-IPN, México*; A. Garcia-Sotelo, V. Altuzar, M. Melendez-Lira, A. Mendoza-Galván,* Cinvestav-IPN, México*; S. Jiménez-Sandoval,* Cinvestav-IPN, México, Mexico

Silicon nitride SiN@sub x@ is a widely used compound in the area of sensors because its electric an optoelectronic properties when it is grew at temperatures lower than 400°C. Also it is employed as buffer layer to deposit films of metallic nanoparticles which are employed as seed for nanotubes grown. We report details of the deposition of SiN@sub x@ thin films by reactive R.F. sputtering on silicon along with results of their structural and optical characterization. The effect of substrate temperature and power intensity of the radiofrequency on films properties were evaluated. Radiofrequency power intensities between 100 and 300 W and substrate temperatures between 100 and 300 °C were studied. Structural and optical characterization were carried out by X-ray diffraction, energy dispersive of X-ray spectroscopy, atomic force microscopy and UV-Vis, Raman and ellipsometry spectroscopies. As expected results indicated that SiNx was produced with optical and structural properties depending on growth parameters. Results are discussed taking in account the stoichiometry obtained under the different growth conditions and the possibility of a porous structure of SiN@sub x@. @FootnoteText@ *Work partially funded by CONACyT-Mexico.

TF-MoP38 Optical and Charge Transport Properties of p-type (CdTe)@sub x@Cu@sub y@O@sub z@ Films: a Novel Material for Photovoltaics and other Optoelectronic Applications, ***S. Jiménez-Sandoval**,* Cinvestav-IPN, Mexico*; J. Carmona-Rodríguez,* Benemérita Univerisidad Autónoma de Puebla, Mexico*; O. Jiménez-Sandoval,* Cinvestav-IPN, Mexico*; R. Lozada-Morales,* Benemérita Universidad Autónoma de Puebla, Mexico*; M. Meléndez-Lira, C.I. Zúniga-Romero,* Cinvestav-IPN, Mexico

Cadmium Telluride is a technologically important semiconductor material for optoelectronic applications; more specifically, for photovoltaic applications and infrared detection. The search for CdTe-based materials that may improve some of the still difficult matters regarding CdTe-based technology is currently underway. This work reports the continuation of our previous work on Cu@sub x@Cd@sub 1-x@Te@footnote 1@ and on Cd-Cu-Te-O systems@footnote 2@ by presenting the structural, optical and electrical properties of (CdTe)@sub x@Cu@sub y@O@sub z@ films grown by reactive rf-magnetron co-sputtering; it is shown that the optical and charge transport properties may be tailored by changing the relative concentration of the four elements. The films were obtained by co-deposition from CdTe and Cu targets under a controlled oxygen flow rate of 11 sccm. The power applied to the Cu target was 0, 10, 20, 30, 40, and 50 W, for different runs. The X-ray diffraction patterns indicated that the films are a mixture of CdTe-type cubic/hexagonal phases; however, it was observed that the hexagonal phase was favored for higher copper concentrations. The chemical composition was analyzed by energy dispersive spectroscopy. The results indicated that the atomic concentration of Cd and Te has nearly identical values in all samples, and decreases as the copper concentration increases from zero to 25 at.%. For films grown with 40 and 50 W in the copper target x=y=z=0.25. The bandgap varied from 1.62 eV (no Cu) to 1.48 eV (25 at.% Cu), a value quite appropriate for the absorbing layer in a solar cell. The four probe method was useful to determine the p-type resistivity of the films grown with Cu powers of 20 W and above. The values obtained ranged from 1.6 x10@super 3@ to 6.5x10@super -3@ ohm-cm. @FootnoteText@ @footnote 1@ S. Jiménez-Sandoval, S. López-López, B.S. Chao, M. Meléndez-Lira, Thin Solid Films 342 (1999)1.@footnote 2@ S. Jiménez-Sandoval et al., To be published (2005).

TF-MoP39 Influence of Ga Doping Level on the Properties of ZnO-Gax Films prepared by Radio Frequency Magnetron Sputtering, *H.C. Pan, C.Y. Su, C.N. Hsiao,* National Applied Research Laboratories, Taiwan*; S.-P. Lin,* ***C.-S. Chiou**,* Yuan Ze University, Taiwan

Gallium doped zine oxide (GZO) thin films are prepared by radio frequency sputtering on the Corning glass using a co-sputtering technique varying sputtering power of Ga@sub 2@O@sub 3@ target as the Ga doping source. The structural, electrical and optical properties of the GZO films are investigated in terms of the deposition conditions such as the Ga@sub 2@O@sub 3@ content in the film, partial oxygen pressure (O@sub 2@ /Ar ratio), film thickness, working pressure and film thickness. The optical and the electrical properties of GZO films were investigated by spectrometer, Hall effect measurement, X-ray diffractometery (XRD), atomic force microscopy (AFM), conducting atomic force microscopy (CAFM) and X-ray absorption near-edge spectroscopy (XANES). The deposited GZO films at room temperature were polycrystalline with a hexagonal wurtzite structures and preferential orientation along (002) plane, regardless of the Ga content. The crystallinity and grain size of the IZO showed an increasing tendency as function of the film thickness. The resistivity of the GZO prepared with around 2 wt.% Ga content in film composition is about 8x10@super -4@ @ohm@-cm and depends on the Ga doping level. The average optical transmittance of a 30 nm-thick film in the visible region (400 nm ~ 700 nm) is about 85%. The optical band gap depends on the Ga doping level is in the range of 3.4 ~ 3.5 eV. Chemical change of different Ga doping level in zinc oxide films was investigated using XANES. Intensities of the peaks appearing at the same energy of ZnO in XANES spectra were decreased with the Ga doping level.

TF-MoP41 The Effect of Ion-beam Assisted Deposition on the Electrical Properties of Indium Zinc Oxide Thin Films Investigated by Conducting Atomic Force Microscopy, ***C.Y. Su**,* National Applied Research Laboratories, Taiwan*; H.C. Pan,* National Applied Research Laboratories*; M.H. Shiao, C.N. Hsiao, K.N. Lee,* National Applied Research Laboratories, Taiwan

Indium zinc oxide (IZO) thin films with 5 wt.% and 10 wt.% of zinc oxide were prepared as the anode layer for organic light emitting diodes (OLEDs). The film deposition process gave a significant influence on device characteristics, and considerable improvements due to the energetic ion bombardments during ion-beam assisted deposition (IAD) were obtained. These improvements are even over the conventional vacuum deposition results. The conducting atomic force microscope (CAFM) that was self-established from a commercial atomic force microscope at ITRC (Instrument Technology Research Center) was employed to investigate the surface morphologies and corresponding electrical properties. And the experiment results suggest that the IAD has the possibility of controlling two factors: the growth morphology and surface electrical properties of the IZO thin films. Including lower roughness (Rms changed from 2.15 nm to 1.50 nm) and higher conductivity (>10@super 3@ @ohm@@super -1@cm@super -1@). The IAD gave uniform surface coverage, which means the initial film growth topography consist of well-distributed small grains other than coagulated islands. The current images that were simultaneously scanned and captured with the topographic images indicate improvement of surface electrical properties from the nano-scale surface inspection of the IZO thin films. The basic principles and mechanisms of this CAFM system are also described.

TF-MoP42 Optical and Electrical Properties of Sc-doped ZnO Thin Films Prepared by RF Magnetron Sputtering, ***M.H. Shiao**,* National Applied Research Laboratories, Taiwan*; C.C. Jaing, Y.J. Huang,* Ming Hsin University of Science & Technology, Taiwan*; H.C. Pan, C.Y. Su, C.N. Hsiao, K.N. Lee,* National Applied Research Laboratories, Taiwan

Scandium-doped zinc (ZnO:Sc) oxide thin films were prepared on Corning 1737 glass by r.f. co-sputtering of ZnO and Sc@sub 2@O@sub 3@ targets at various deposition temperatures ranging from room temperature (RT) to 300°C and different oxygen partial pressures. Composition of the ZnO:Sc thin films was analyzed by energy dispersive X-ray spectroscopy (EDS), and the crystalline structure was examined by X-ray diffraction (XRD). Optical transmittance of the films was measured by a Perkin Elmer Lambda 900 spectrometer. Electrical resistivity, Hall mobility and carrier concentration were investigated by a Hall effect measuring system. Surface morphologies and corresponding electrical properties of ZnO:Sc thin films were observed by adopting a conducting atomic force microscope (CAFM). From experimental results, the deposited thin films showed good conductivity (@>=@ 10@super 2@ @ohm@@super -1@cm@super -1@) and high optical transmittance (@>=@ 85%) in the wavelength range of 400-800 nm. The resistivity of ZnO:Sc thin films increased and the preferred orientation was changed from (002) to (103) as the oxygen partial pressure increased.

TF-MoP43 Characteristics of High-k Gate Dielectric Formed by Oxidation of Multi-layered Metal Films Deposited Directly on the Si Substrate by Sputtering, ***M.T. You**, S.-W. Jeong, H.J. Lee,* Sungkyunkwan University, Korea*; Y.-H. Roh,* Sungkyunkwan University, Korea, Republic of Korea

Recently, we demonstrated that the oxidation of the Hf metal film deposited directly on the Si substrate by sputtering results in the HfSi@sub

x@O@sub y@/HfO@sub 2@ stack layer with excellent electrical properties and high thermal stability in direct contact with Si. In this work, we further investigated the physical and electrical properties of high-k oxide films obtained by the oxidation and annealing of the multi-layered metal films (e.g., Hf/Zr/Hf, Zr/Hf/Zr, etc.) Thin metal films with the typical thickness of 1-2nm were deposited on the Si substrate alternately by rf-magnetron sputtering. Oxidation was performed at 500°C for 120min using the conventional furnace under O@sub 2@ ambient. Post oxidation annealing was done at several temperatures (i.e., 500, 700, and 900°C) for 90sec using a rapid thermal processor(RTP) under either N@sub 2@ or O@sub 2@ ambient. Data of HF C-V, I-V and Fowler-Nordheim tunneling (FNT) electron injection were analysed. TEM and XPS techniques were used to investigate the structural changes of the high-k films due to post oxidation annealing. The multi-layered high-k oxide films were formed after oxidizing the multi-layered metal films deposited directly on the Si substrate. The subsequent RTP annealing at high temperature (700°C) not only results in the poly-crystallization of the multi-layered high-k oxide films, but also causes the inter-diffusion of either Hf or Zr, resulting in the multi-layered high-k gate oxide. For example, HfSi@sub x@O@sub y@/HfO@sub 2@/intermixed-layer(IL)/ZrO@sub 2@/intermixed-layer(IL)/HfO@sub 2@, films were formed, if the Hf/Zr/Hf metal films were oxidized and subsequently annealed. The inter-diffusion of metal atoms improves electrical properties in general. In addition, the data obtained from the FNT electron injection either from the gate electrode or from the Si substrate indicate that the defect density changes depending on the annealing conditions.

TF-MoP44 Characterization of Barium Zirconium Titanate Thin Films as Tunable Materials Prepared by rf Magnetron Sputtering, ***W.-A. Lan,*** National Tsing Hua University, Taiwan, R.O.C.*; T.-B. Wu,* National Tsing Hua University, Taiwan, R.O.C., Republic of China

There are a large number of perovskite structure ABO@sub 3@ ceramics with nonlinear dielectric properties being studied. For Ba(Zr@sub x@T@sub 1-x@)O@sub 3@ (BZT), with increasing the Zr content, the dielectric constant decreases and the leakage current is reduced by suppressing the formation of Ti@super 3+@ and hopping conduction. The Zr@super 4+@ ion is chemically more stable than the Ti@super 4+@ and has a larger ionic size to expand the perovskite lattice and shifts the ferroelectric-to-paraelectric phase transition temperature toward room temperature. In this work, the sputtered BZT ferroelectric thin films with different Zr substitution under several deposition conditions were investigated. The BZT thin films were deposited by rf sputtering using a 2 inch target. The test structure was made in M-I-M structure. The bottom electrode is (001)-textured LaNiO@sub 3@ (LNO) conductive oxide which was deposited on the Pt/Ti/SiO@sub 2@/Si substrate by rf sputtering with a thickness of 200nm. The Ba@sub x@(Zr@sub y@Ti@sub 1-y@)O@sub 3@ targets were prepared by solid state mixing method using single phase calcined powders x of BaZrO@sub 3@ and (1-x) Ba@sub 2@TiO@sub 4@. The mixing ratio , x, were 0.15, 0.2, 0.25. The sputtering was conducted under different rf-sputtering power, substrate temperature, Ar/O@sub 2@ ratio and target stoichiometry. The deposition time was controlled at 1 hour to study the effects of sputtering conditions. Platinum top electrode of 75 nm thick was deposited by rf sputtering at room temperature. Lift-off process was used to defined the pattern in circles with different radius. The crystalline phases of the films were examined with x-ray diffraction. Cross-sectional morphologies and thickness of the films were examined by field emission SEM. The dielectric properties of the films were measured with 4192A from 1 kHz to 1MHz. The voltage dependence of dielectric constant and loss tangent was measured with 4284A at 1 MHz.

TF-MoP45 Electrical and Optical Characteristics of MIS Structure using the a-C and a-C:H Films Grown by Closed-Field Unbalanced Magnetron Sputtering, ***Y.S. Park,*** *B. Hong,* Sungkyunkwan University, Korea

With extreme hardness of diamond and synthetic diamond-like carbon (DLC), carbon based materials were used mainly as a cutting tool coating and as an abrasive material. Since then, carbon based materials have been expanded into the market of electronics, optics and acoustics as well as coatings due to excellent electrical properties. Amorphous carbon (a-C) and hydrogenated amorphous carbon films were deposited on p-type silicon and glass substrates by a closed-field unbalanced magnetron (CFUBM) sputtering method. We have investigated the effect of various DC bias voltages on microstructure, electrical conductivity and optical properties. The samples were characterized with Raman spectroscopy, XPS, electrical resistivity, current-voltage (I-V) and capacitance-voltage (C-V) curves, UV-visible and FT-IR. The a-C and a-C:H films prepared by CFUBM sputter in this study show good conducting properties.

TF-MoP47 Thermochromic La@sub 1-x@Sr@sub x@MnO@sub 3@ (x = 0.1, 0.175, and 0.3) Smart Coatings Grown by Reactive Pulsed Laser Deposition, ***M. Soltani,*** *M. Chaker,* INRS-Energie, Matériaux et Télécommunications, Canada*; X.X. Jiang, D. Nikanpour,* Canadian Space Agency, Canada*; J. Margot,* Université de Montréal, Canada

Thermochromic Sr-doped LaMnO@sub 3@ thin films exhibit a metallic-to-insulator phase transition from low to high temperature. The transition temperature can be controlled by varying the concentration of Sr@super 2+@ ions dopant in the films. Using a reactive pulsed laser deposition (RPLD) process, we have successfully fabricated thermochromic La@sub 1-x@Sr@sub x@MnO@sub 3@ (LSMO) smart coating at relatively low deposition temperature (about of 500 °C), and without post-annealing. Silicon (100) and sapphire (1000) were used as substrates in order to study the substrate effect on the deposited films. The RPLD of LSMO films was performed in a background gas mixture of Ar and reactive O@sub 2@, from three La@sub 1-x@Sr@sub x@MnO@sub 3@ targets with different Sr doping concentrations (i.e. x = 0.1, 0.175, and 0.3). It was found that the deposited LSMO films perfectly adhere to the wurtzite Al@sub 2@O@sub 3@ as well as to the cubic Si substrate. Their perovskite structure was confirmed by X-ray diffraction (XRD). The composition of LSMO coatings was investigated by X-ray photoelectron spectroscopy (XPS) analysis of the La, Sr, Mn, and O bands. The metal-to-insulator phase transition of LSMO-coated sapphire was investigated by measuring the temperature dependence of the sheet electrical resistivity using the standard four-point probe technique. At room temperature, a thermal coefficient of resistance (TCR) about -1.5 % per °C was achieved in these films. Finally, the potential applications of these thermochromic smart coatings will be discussed.

TF-MoP48 TiN and TiO@sub2@:Nb Thin Film Preparation using Hollow Cathode Sputtering with Application to Solar Cells, ***S.Y. Guo,*** Energy Photovoltaics, Inc.*; W.N. Shafarman,* University of Delaware*; A.E. Delahoy,* Energy Photovoltaics, Inc.

Hollow cathode sputtering has found many applications for deposition of functional thin films. In particular, excellent TCOs, including In@sub 2@O@sub 3@:Ti, have been produced by reactive-environment hollow cathode sputtering.@footnote 1@ Recently, we have investigated titanium-based thin films using similar methods. TiN is well known for its excellent conductivity, inertness, and good optical reflectivity at long wavelengths. These properties make it a potential IR-reflective back contact material suitable for ultra-thin CIGS solar cells. Using a pulsed power, linear hollow cathode source, TiN films on Mo-coated glass were achieved by adopting a combination of four critical parameters. Two of these were the passing of nitrogen through the cathode cavity and magnetic field assistance. Electrical and optical properties of the films were measured. The optical emission spectrum of the Ar/N@sub 2@/Ti plasma and film XRD measurements will be reported. The effect of deposition parameters such as nitrogen flow rate, pressure, substrate bias and substrate temperature have also been studied. CIGS solar cells have been successfully fabricated on TiN and a conversion efficiency of 11.7% has so far been achieved. Transparent and somewhat conductive TiO@sub 2@ films doped with Nb were also prepared. The electrical and optical properties of these films will be reported. @FootnoteText@ @footnote 1@ A.E. Delahoy and S.Y. Guo, J. Vac. Sci. Technol. A, Jul/Aug 2005.

TF-MoP49 Optical Constants of (CdTe)@sub 1-x@Al@sub x@x Thin Films, *J. Jimenez Montecinos,* UAM-Azc., Mexico*;* ***A. Mendoza-Galvan,*** Cinvestav-IPN, Mexico*; M. Zapata-Torres,* CICATA-IPN, Mexico*; S. Jimenez-Sandoval, M. Melendez-Lira,* Cinvestav-IPN, Mexico

We have prepared (CdTe)@sub 1-x@Al@sub x@ thin films by R.F. co-sputering in order to evaluate their capability as a photovoltaic material. CdTe and Al were employed as targets. Samples were deposited on commercial glass substrates at substrate temperature of 400 °C. The aluminum content was controlled through the R.F. power intensity applied on the aluminum target. Samples were characterized by X-ray diffraction and EDX. Surface morphology, monitored by atomic force microscopy, showed a dependence with preparation details. A blue band gap shift is clearly observed by absorption spectroscopy as function of aluminum content of the films. Raman spectroscopy present a FHMW increase and small shift toward high wavenumbers in the LO CdTe-like mode. From ellipsometry measurements we obtained the pseudo dielectric function obtaining information about the critical points. Ellipsometry results also shown the shift in critical point energies as function of aluminum content. @FootnoteText@ @footnote 1@ Work partially funded by CONACyT-Mexico.

TF-MoP50 Inhomogeneous Rarefaction of the Process Gas in a Direct Current Magnetron Sputtering System, ***F.J. Jimenez***, *S.D. Ekpe, S.K. Dew,* University of Alberta, Canada

The interactions between energetic particles and the sputter gas in a magnetron sputtering system have strong effects on the growth, structures and properties of the film. These interactions result in inhomogeneous rarefaction of the gas in the space between the target and substrate, and affect the transport of particles towards the substrate. A hybrid Monte Carlo and fluid model is developed to simulate 3-dimensional gas rarefaction due to the sputtering of metals in Argon, Neon and Krypton. The governing equations are solved iteratively in a 3D space with a non-uniform grid (octree). Collision events between the sputtered particles and the process gas are assumed as the dominant source of gas heating, however, the effect of the reflected neutrals is also included in the model. Gas rarefaction profiles have been predicted for different process conditions. Results compare well with experimental results. The location of the highest rarefaction depends strongly on pressure, power, target material and location of the substrate plane relative to that of the target. The extent of rarefaction depends further on the thermal conductivity of the gas. Materials with high sputtering yield, like Silver, show more rarefaction than those with low sputtering yield, like Tungsten and Aluminum. Tungsten, as a result of a higher target to gas mass ratio, shows more of the effect than Aluminum. For a 75 mm target at 300 W and 10 mTorr a rarefaction of about 65% is obtained for the sputtering of Aluminum in Argon gas, with the substrate plane located at 10 cm in front of the target.

TF-MoP51 Influence of Flux Anisotropy on Microstructure of Sputter Deposited Cr Films, ***S.Yu. Grachev***, *J.-D. Kamminga, G.C.A.M. Janssen,* Netherlands Institute of Metals Research, the Netherlands

Sputter deposition is widely used to produce metal and compound thin films. The immanent feature of sputter deposition is that the arriving flux possesses a wide angular distribution. The flux distribution at the coated surface is influenced by the pressure of sputtering gas and by the tilt/rotation of the substrate. It is known, that the anisotropy of the flux distribution can become a source of anisotropic microstructure and, as a consequence, the anisotropy of film properties. In our study we concentrated on the influence of the flux anisotropy on the microstructure of Cr films. There are several sources for anisotropy in the Hauzer HC 750 industrial deposition system we used. First, the elongation of the target (600x120mm@super 2@) induces a flux distribution with arriving angles up to 60° to the substrate normal. This flux distribution results in strong anisotropy of the surface morphology and in-plane crystallographic texture. Second, we tilted the substrate around an axis parallel to the target elongation. This introduced anisotropy in the perpendicular direction. As a consequence, the in-plane texture of the film was turned by 90° with respect to the texture in films grown on substrates parallel to the target. Planetary rotation around axes parallel to the target elongation was also studied. The tilt of the columnar microstructure of samples on tilted substrates is dependent on Ar pressure. At low Ar pressure the tilt is close to the substrate tilt (43° for 45° substrate tilt). The tangent rule predicts the inclination of 26.5°. The discrepancy is attributed to the complicated flux angular distribution from the elongated target. At higher Ar pressure the tilt of the columnar structure was smaller due to the smearing out of the flux distribution.

TF-MoP52 Plasma Diagnostics of Inductively Coupled Plasma Assisted Magnetron Sputtering for Reactive Deposition of MgO, ***J. Joo***, Kunsan National University, Korea

Real time process diagnostics for reactive deposition of MgO were done to optimize high deposition rate and high transparency of the deposited films in rectangular (5 inch x 25 inch) target system. Inductively coupled plasma was adopted to enhance reactivity of oxygen for low temperature deposition of MgO. Using bipolar pulse power supply at 150 kHz, depositiion rate of 30 nm/min was achieved with 500 W pulse and 300 W of ICP power, which gave 90% of UV/VIS transparency(300 nm - 800 nm). For more intelligent feedback control, several real time diagnostics including OES, discahrge voltage and current waveform, QMS were carried out. With aid of ICP, metal ion signal showed very strong correlation with the reactivity of the plasma.

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