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

Thin Film Poster Session II

TF-ThP1 Effects of Substrate Temperature on the Microstructure and Mechanical Properties of Multi-Element (TiVCrZrTa)N Coatings, ***M.H. Shiao***, National Applied Research Laboratories, Taiwan, Republic of China, *C.C. Jaing*, *K.S. Tang*, Minghsin University of Science and Technology, Taiwan, Republic of China, *C.T. Lee*, *C.Y. Su*, Instrument Technology Research Center, Taiwan, Republic of China, *Z.C. Chang*, National Chin-Yi University of Technology, Taiwan, Republic of China, *C.N. Hsiao*, National Applied Research Laboratories, Taiwan, Republic of China

Multi-element nitride thin films of TiVCrZrTa high-entropy alloy were prepared by reactive RF magnetron sputtering technique with different substrate temperatures ranging from 25 ℃ to 400 ℃ . The microstructure and mechanical properties of the deposited nitride thin films were investigated by scanning electron microscope (SEM), atomic force microscope (AFM), transmission electron microscope (TEM), X-ray diffraction (XRD), nanoindenter, and phase shifting interferometry techniques. SEM and TEM results show that (TiVCrZrTa)N thin films exhibit a columnar structure. XRD and TEM diffraction results show a face-centered-cubic structure, and the intensity of (111) and (200) peaks increases with substrate temperatures in X-ray diffraction result. AFM measurements show the surface roughness of TiVCrZrTa nitride thin films increases slightly from 2.9 to 3.5 nm. Furthermore, the residual stress of (TiVCrZrTa)N thin films presents compressive stress and increases from 1.5 to 1.9 GPa with increasing substrate temperatures. The hardness and elastic modulus of TiVCrZrTa nitride thin films are approximate 26.5 and 240 GPa respectively, independent of the substrate temperatures.

TF-ThP2 Pulsed DC Magnetron Sputtered Nickel Thin Films: A Study of Stress, Density and Electronic Properties, ***E.D. Jones Jr.***, *D.P. Adams*, *M.A. Rodriguez*, Sandia National Laboratories

With the advent of pulsed magnetron direct current (DC) sputter deposition technology, there have been gains made in the deposition of various inorganic thin films.[1] Most notably used for reactive sputtering of oxides and nitrides, pulsed DC sputtering has led to the deposition of dense coatings with improved properties such as adhesion and wear. The property changes have been attributed to the differences in flux and energy of the species involved with growth.

In this work, we explore the effects of using pulsed DC methods for sputtering monolithic ~ 200 nm-thick nickel films. The power supply used for this study is the Advanced Energy Pinnacle Plus 10kW series, which allows for continuous or pulsed DC sputtering modes. We demonstrate the effects of argon sputter pressure (1-25mT) on residual stress, film density and film resistivity for various pulsed DC processes and contrast these with the properties formed during continuous DC sputtering. For the pulsed DC experiments we show how these three film properties (stress, density and resistivity) depend on argon pressure for each of four different pulse frequencies (50, 150, 250 and 350 kHz - reversal time is held at 1.0 μs). Residual stress is determined through wafer curvature methodologies – working within the assumptions of Stoney's equation[2]. Film density determined using x-ray reflectivity. Room temperature resistivity is determined using four-point probe instruments.

In general, the stress can be tailored during pulsed DC and constant DC sputtering by adjusting argon sputter pressure. For most conditions, the films are in a state of in-plane tensile stress after deposition and cooldown although near-zero stress can be obtained at lower pressures. Pulse frequency is shown to have a minor effect on residual stress for most processes. However, frequency has a greater effect on stress at the lower sputter pressures (1-5mT). We further evaluate the stress of all films in terms of intrinsic and extrinsic contributions to isolate the role of pulsed DC sputtering process parameters on intrinsic stress. Extrinsic stress effects (due to mismatch in thermal expansion coefficients) are factored out from the final, residual stress using known temperatures achieved during deposition and the mechanical properties of the film and substrate.

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TF-ThP3 Photoluminescence Characterization using Hanle Effect in $Al_xGa_{1-x}As/GaAs$ Quantum Wells Grown on Processed Surfaces, ***J. Hernández-Rosas***, *C. Mejía-García*, IPN, Mexico, *A. Winter*, Universität Bayreuth, Germany, *M. López-López*, IPN, Mexico, *A. Gilinsky*, Institute of Semiconductor Physics SB RAS, Russia, *H. Pascher*, Universität Bayreuth, Germany

In this work, we report the photoluminescence spectroscopy using Hanle effect of a series of quantum well (QW) structures of $Al_{0.3}Ga_{0.7}As/GaAs$ grown by molecular beam epitaxy, which were prepared using different processing of the GaAs buffer layer surface. Each sample consists of three QW's with thicknesses of 7, 5, and 3 nm, respectively. The characterization by photoluminescence spectroscopy was done using several fixed wavelength lasers with circularly polarized excitation at 1.6 K. By means of Hanle effect the interband lifetime τ and the spin lifetime τ_s of the electrons were determined. A polarization change was observed if the photon energy of the exciting light exceeds the difference between the spin orbit band and the conduction band. The intensity of the inverse circular polarization seems to be increased in the samples with better quality. Interband transitions associated to the QW's were calculated using the effective mass approximation method in order to verify the experimental results.

TF-ThP4 Electrical Characterization of GLAD Thin Films, ***A. Lalany***, *R.T. Tucker*, University of Alberta, Canada, *M.D. Fleischauer*, National Institute for Nanotechnology (NRC Canada), *M.J. Brett*, University of Alberta, Canada

Glancing Angle Deposition (GLAD)[1] thin films are increasingly used in optical and sensor devices that benefit from the unique refractive properties or ultra-high surface area. Extending the use of GLAD films to energy devices, epitomised by the fields of photovoltaics[2] and fuel cell catalysis[3], increases the complexity in desired film requirements. High electrical conductivity along the length of GLAD structures - normal to the substrate plane - is necessary in order to exploit the high surface area of GLAD films in electronic devices. To date, GLAD has been applied to a variety of metals and conductive oxides[4-6], and preliminary trends outline a relationship between the angle of incident flux, film density and in-plane resistivity. More specifically, it has been found that as the oblique deposition angle increases, the in-plane resistivity also increases. This relationship has been attributed to a decrease in film density resulting in diminished conductive pathways. Electrical anisotropy has also been observed, with differing in-plane resistivity for parallel and perpendicular directions with respect to the nanocolumns formed.[4-6] A thorough study of both in-plane and through-post conductivity as a function of film composition, morphology, porosity, and crystallinity / phase is required to understand the complex interplay between film morphology and corresponding electrical properties. Quantifying differences between vertical and lateral-plane characteristics of GLAD films requires expanding on established techniques for in-plane measurements (which largely neglect morphological effects) and tailoring techniques to apply directly to GLAD films. It has been found that external boundaries begin to dominate standard bulk scattering mechanisms as film thickness decreases, resulting in an inverse relationship between film thickness and resistivity.[7] Subsequently, the extensive boundaries present in GLAD films between and within individual features can result in complex electrical behaviour. We will quantify the variations in both in-plane and through-post conductivity through the use of direct and indirect experimental approaches, and relate the results to deposition parameters suitable for forming GLAD films of desirable conductivity.

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TF-ThP5 Atomic Layer Deposition of Titanium Nitride Using Titanium Tetrachloride and Hydrazine, ***D. Seghete***, *A.I. Abdulagatov, V.R. Anderson, A.S. Cavanagh, W. Wang, S.M. George*, University of Colorado at Boulder

The atomic layer deposition (ALD) of high quality metal nitrides at low process temperatures has remained a challenge. The use of organometallic precursors to reduce the deposition temperature can lead to carbon incorporation and poor electrical performance. One possibility is to use halide precursors together with hydrazine instead of ammonia for the ALD of metal nitrides. Thermochemical calculations indicate that heats of reaction are more favorable and reaction temperatures should be lower with hydrazine. In this work, TiN ALD was performed using titanium tetrachloride ($TiCl_4$) and hydrazine (N_2H_4). *In situ* quartz crystal microbalance (QCM) measurements revealed a TiN ALD growth rate of 16 ng/cm^2 at 225°C. The $TiCl_4$ and N_2H_4 reactions were both observed to be self-limiting. At higher temperatures, TiN ALD is difficult to examine using the QCM because of thermal stability issues. X-ray diffraction (XRD) and X-ray reflectivity (XRR) studies revealed that TiN ALD deposited at 275°C resulted in the purest cubic polycrystalline TiN film. TiN ALD at 275°C also displayed the highest growth rate of 0.36 Å/cycle and a film density of 4.7 g/cm^3. Fourier transform infrared (FTIR) studies of the $TiCl_4$ and N_2H_4 reactions at 275°C observed that primary (-NH_2) and secondary (-NH) amines are formed after hydrazine exposures. The FTIR spectra contained no evidence of any chlorine-containing salt on the surface. Elemental analysis of the TiN ALD grown at 275°C revealed no chlorine impurities within the X-ray photoelectron (XPS) instrument detection limit of 1 at%. However, oxygen was present at 14 at% that is attributed to oxidation after exposure to air. The use of hydrazine should facilitate the deposition of TiN ALD films at process temperatures <300°C.

TF-ThP6 Understanding Some Pitfalls and Loopholes in Routine Characterization and Metrology of Thin Films for Solar Cells, ***M. Scott***, *J. Burst, T. Gessert*, National Renewable Energy Laboratory

We show that even the more ordinary metrology tools routinely used to evaluate thin films demonstrate some subtle, and some not so subtle, pitfalls which may lead to unexpected, and perhaps unnoticed, error in the measurement. In the extreme case, of course, one may altogether get the "wrong" answer. We focus on some of the primary tools used in the evaluation of thin films for photovoltaic applications. Empirical results from commercially available spectrophotometer, Hall, profilometer and other characterization tools are presented. We show, for example, that the commonly presented, but often unnoticed and not discussed, mismatch in reflectance data at the detector changeover (~800 nm) is readily explained and satisfactorily eliminated.

TF-ThP7 Deposition of Relatively Thin Highly C-axis Oriented AlN Films for High Frequency Electro-Acoustic Devices, ***V. Felmetsger***, *P. Laptev*, OEM Group Inc.

Thin film bulk acoustic resonators (FBAR) and bulk acoustic wave (BAW) filters based on piezoelectric aluminum nitride (AlN) thin films are widely employed for different wireless applications. As the resonance frequency of the resonator is determined by the thickness of the AlN layer, there is essential interest of using ultra-thin 100-200 nm films to extend the current technology from 1-2 to 5-10 GHz range. Reactive magnetron sputtering is a method of choice enabling formation of the films with a high degree of c-axis texture; however it is challenging to deposit such thin films with acceptable piezoelectric coefficients due to their drastically downward crystallinity compared to 500-2000 nm thick films required for lower frequency devices.

In this study, we use reactive sputtering technology with a dual cathode ac powered S-Gun magnetron [1]. The quality of the c-axis crystal orientation is characterized by the full width at half maximum (FWHM) of the AlN (0002) X-ray diffraction peak. AlN films deposited by the S-Gun on low-doped Si wafers exhibit a strong crystal orientation, which is improved with increasing film thickness. It is more sophisticated to achieve the same crystal orientation when the film is deposited on a metal bottom electrode, as it is required for the FBAR and BAW devices. Therefore, formation of well-textured underlying electrodes is essential, especially if the AlN films are relatively thin.

The crystal orientation of common electrode metals and alloys deposited on Si, SiO_2, SiC, and diamond-like substrates is greatly enhanced by depositing a thin AlN seed layer underneath the metal. In the paper, we will discuss the critical conditions and process steps required for producing ultra-thin highly textured AlN films. For this purpose, we have developed a two-step sputter deposition process enabling better conditions for AlN nucleation. After preliminary rf plasma treatment of the substrate surface, the first 20-50 nm thick AlN layer is deposited at elevated temperature with higher nitrogen concentration in Ar-N_2 gas mixture, stimulating growth of higher quality columnar grains with the increase of AlN film thickness.

The results obtained for 100 and 200 nm thick AlN films deposited onto different metal electrodes (Mo, Cr, Ir) are presented in the paper.

The sputter technology has demonstrated high efficiency in producing very thin (100 nm) AlN films exhibiting superior crystallinity with FWHM < 2.5˚on Mo electrode, which is equal to or even better than the value for the deposition on Si substrates.

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TF-ThP8 Properties of Transparent Conducting Sn-doped In_2O_3 Films Deposited by Pulsed Electron Deposition, ***M. Chen***, *V.C. Rincon, H.V. Nampoori, R.M. Frazier, S. Kotru*, The University of Alabama

Sn-doped In_2O_3 (ITO) thin films find wide applications as an electrode material for photovoltaic devices. Optical transparency, electrical properties and surface roughness are the major parameters which need to be optimized for obtained device quality films for such applications. In the present work 100 nm thick ITO films were deposited on quartz substrates at room temperature using a vapor deposition technique, where a pulsed electron beam was used to ablate the target material. A series of films were deposited by varying the oxygen pressure in chamber during growth from 3.1mTorr to 20mTorr. Various characterization techniques were applied: x-ray diffraction, atomic force microscopy, four-point probe, Hall analysis, and Spectrophotometry were used to investigate the structure, surface morphology, electrical, and optical properties of these films. The best samples had a film resistivity of $6.8E^{-4}$ohm*cm, and an average transmittance of 80% in the visible spectrum. The influence of post annealing on the film properties was also be presented.

TF-ThP9 Synthesis and Characterization of Molybdenum Oxynitride Thin Films, ***J.Y. Park***, *Y.C. Kang*, Pukyong National University, Republic of Korea

Molybdenum oxynitride films were deposited on the p-type Si(100) substrate using radio frequency (r.f.) magnetron sputtering technique at different nitrogen gas ratio from 0 to 100%. Molybdenum oxynitride films were investigated by atomic force microscopy (AFM), X-ray diffraction (XRD), scanning electron microscopy (SEM), spectroscopic ellipsometry (SE), and X-ray photoelectron spectroscopy (XPS).

The roughness of molybdenum oxynitride films were slightly increased up to 13% of nitrogen gas ratio then decreased significantly. XRD results show that the crystal structure was metallic Mo(110) at the 0% of nitrogen gas ratio. The thickness of molybdenum oxynitride films was decreased to 70 from 800 nm with increasing nitrogen gas ratio. The thickness deduced from SE experiment was well consistent with the result of SEM and band gap was calculated using extinction coefficient values obtained by SE. The high resolution XP spectra of Mo 3d, O 1s, and N 1s were deconvoluted to get more chemical information and valence band maximum was determined with valence band region XP spectra of molybdenum oxynitride thin films.

TF-ThP10 Effects of Non-Uniformity for GaN Deposition by the Structure of Gas Inlet in MOCVD, *W. Yang, K. Hong, J. Joo,* Kunsan National University, Republic of Korea, *S. Lee,* ***T. Lee***, JUSUNG Engineering, Republic of Korea

GaN deposition equipment and processes for white LED (Light Emitting Diode) at MOCVD (Metalorganic Chemical Vapor Deposition) were numerically modeled to analyze the effects of reactive gas introduction strategy. The source gases, TMGa and NH_3, were injected from shower head on the top of chamber, and the carrier gases, H_2 or N_2, were introduced from two types of structure: vertical injection and horizontal injection. Wafers are setting on the holder at a radial distance of between 100 mm and 150 mm. The non-uniformity of deposition rate for vertical injection and horizontal injection was 1.9 % and 2.8 %, respectively. And In case of using the N_2 carrier gas instead of H_2, the uniform deposition zone was increased by 20%.

TF-ThP11 In Search of New Multiferroics: Thin Film Synthesis and Characterization of Titanates of the $MTiO_3$ (M=Ni, Fe, Mn, Co) Family, ***R. Sanghavi***, *T. Varga, T. Droubay, P. Nachimuthu, V. Shutthanandan, S. Thevuthasan*, Pacific Northwest National Laboratory

Today's challenge in multiferroics is to identify materials in which polarization and magnetization – normally considered contraindicated properties are strongly coupled. Recent theory calculations predicted that the family of compounds $MTiO_3$ (M = Mn, Fe, Ni), in a certain polymorphic structure (acentric *R3c*), are promising candidates where a polar lattice distortion can induce weak ferromagnetism (WFM). Guided by these insights, a phase of $FeTiO_3$ has been prepared more recently, which exhibits both ferroelectricity (FE) and WFM. However, the possible coupling between its polarization and WFM remains to be demonstrated. This demonstration may require the use of aligned single crystals to show

that the magnetic and polar domains can be switched in concert. Results of the synthesis of the thin films of structurally analogous $MTiO_3$ compounds, and their characterization with a focus on the possible coupling between FE and WFM are reported . This fundamental study can be used to develop functional magnetic devices such as bio-sensors in which the magnetization can be controlled by electric field

TF-ThP12 Properties of ALD Al_2O_3 Protective Coatings, *P.J. Evans*, Australian Nuclear Science and Technology Organisation, *Y. Murai*, Nagaoka University of Technology, Japan, *M. Lindsay, J. Davis*, ***G. Triani***, Australian Nuclear Science and Technology Organisation

In recent years, atomic layer deposition (ALD) has emerged as a technology platform for nanofabrication [1]. This interest has evolved from its intrinsic advantages; inherent thickness control, the ability to prepare highly conformal pin-hole free films, low temperature film growth and its large area uniformity. These redeeming characteristics have broadened the application of ALD films in such diverse areas as encapsulation of nanoparticles [2], templating of complex structures [3] and the modification of membranes [4].

The deposition of atomic layer protective coatings on flexible polymers and metals is another target application to improve the lifetime performance of functional materials that may be susceptible to degradation [5]. In particular, the ingress of moisture and atmospheric gases as well as the effects of abrasion and thermal cycling can significantly diminish a material's suitability in cases where its bulk properties meet all other requirements. Inorganic barrier coatings on flexible substrates are subject to additional constraints where the mechanical strength and adhesion of the protective coating are particularly important.

In this study, ALD alumina coatings were deposited on flexible substrates including polycarbonate, polyethylene naphthalate (PEN), copper and titanium, to investigate their toughness and adhesion under tensile load. In addition, the effect of deposition conditions on the performance of these protective coatings will be presented.

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TF-ThP13 Temperature Uniformity Issues of Inductive Heating in MOCVD Systems to Fabricate MQW White LEDs, ***K. Hong***, *W. Yang, J. Joo*, Kunsan National University, Republic of Korea

Deposition temperature uniformity of GaN based MQW(multiple quantum well) layers is an important key which affects the wavelength uniformity of white LEDs. Two types of heater were tested: a resistive and inductive heater. Varying the gap between the heater and the susceptor, temperature uniformity was assessed by infra-red images for both cases of a static and a rotating susceptor. The best non-uniformity of resistive heater was obtained at 3 mm gap, 6.2%. Rotating the susceptor at 2.5 rpm over the induction heater gave 4.3% of temperature non-uniformity. Temperature distribution of the graphite susceptor over the induction heater was numerically modelled and agreed with experimental results.

TF-ThP14 Investigation on the Electrical and Optical Properties of ZnO:Al Thin Films by RF Magnetron Sputtering and Annealing, *C.T. Lee, B.H. Liou,* ***D.R. Liou***, *C.N. Hsiao*, Instrument Technology Research Center, Taiwan, Republic of China

ZnO:Al (AZO) thin film was prepared on glass substrate with various substrate temperatures by RF magnetron sputtering deposition. Various substrate temperatures and 500 ℃ annealing on the electrical and optical properties of as-deposited AZO film were investigated by Hall measurement and spectrometer. The minimum resistivity of the as-deposited AZO film was 1.0×10^{-3} ohm cm at the substrate temperature of 300 ℃. After annealing, the resistivity of all films was improved. The optimum resistivity of AZO thin film is 5.6×10^{-4} ohm cm. The average transmittance of AZO thin films in the visible range was decreased with increased substrate temperature. It was found that the minimum resistivity and maximum average transmittance of 82% in the visible range were at substrate temperature of 300 ℃ and after 500 ℃ annealing.

TF-ThP15 Photo-functional Properties for Fe-Added Titanium Dioxide Thin Films Prepared by Reactive Magnetron Sputtering, ***S. Arahara***, *I. Takano, M. Sato*, Kogakuin University, Japan

Since the photoinduced decomposition of water on TiO_2 electrodes were discovered, semiconductor based on photocatalyst has attracted extensive interest. TiO_2 is anticipated as one of materials which are alternative for existing solar cell technology type based on a silicon type. TiO_2 shows relatively high reactivity and chemical stability under UV light whose energy exceeds the band gap of 3.2 eV in the anatase crystalline phase. The sun can provide an abundant source of photons. However, UV light accounts for the only small fraction (~5 %) of the sun's energy compared to the visible region (45 %). Many techniques have been examined to achieve this purpose, including the doping of TiO_2 with transition metals (such as Cr, Fe, Ni, V).

In this study, TiO_2 film has been prepared by reactive magnetron sputtering using a Ti target in an Ar/O_2 gas mixture. Fe addition was performed by Fe sputtering onto those TiO_2 films. Composition and microstructure of these films were investigated by X-ray photoelectron spectroscopy and X-ray diffraction, respectively. Chromatic change of a methylene blue solution was applied to a photocatalytic property. Light irradiation to the TiO_2 film in a methylene blue solution was carried out using a commercial sterilizing lamp as ultraviolet light and artificial sun light as visible light. Transmittance of a methylene blue solution was measured by a spectrophotometer. Furthermore, photocurrent between the TiO_2 film and a platinum electrode was measured by a volt-ampere characteristic using an unresisted ammeter in a KCl solution of 0.5 mol/ℓ.

The crystal structure of TiO_2 turned from a ruttile type into an anatase type with increase of O_2 gas flow rate. Photocatalytic characteristic of an anatase type showed the higher value under ultraviolet light, while the difference in the crystallographic structure was not obserbed under visible light. The effect of adding Fe was obtained at the Fe-added sample basing TiO_2 prepared with O_2 gas flow rate of 1.5 and 2.0 sccm. It was considered that the charge separation between an electron and a hole was enhanced by adding Fe to the TiO_2 surface. The optimum thickness of the Fe film was about 0.1 nm.

TF-ThP16 Control of Reflectivity at Substrate/Resist Interface of Nanometer-scaled Devices by Inorganic Bottom Anti-Reflection Coating (BARC), ***S.-Y. Kim***, Korea Polytechnic College IV, Republic of Korea, *N.-H. Kim*, Chonnam National University, Republic of Korea

As the device has became highly integrated, the more accurate critical dimension (CD) was demended. High contrast resit was also required for the exposure threshold effect. However in this case, the reflectivity between substrate and resist became higher; therefore, the CD swing curve was intesified which was directly influenced by the change of resist thickness. Lastly, the resist notching phenomenon was appeared, which was caused by the reflectivity owing to the shape of sub-layer. It is very important to control the reflectivity between substrate and resist for the precise CD control. The bottom anti-reflective coating (BARC) is one of the most widely used methods. The conventional inorganic BARC has been employed in the metal pattern process of μm-scaled devices with oxynitride. Because the more accurate CD control is necessary for the nm-scaled devices, the resist thickness, the conditions of reflectivity and absorption coefficient, and metal stack as a sub-layer were changed. The standing wave was also observed in the resist profile after metal pattern process of nm-scaled devices. Therefore, the optimization of inorganic BARC was investigated for the application to the nm-scaled devices with the changes of resist thickness and sub-layer. The reflectivity in the interface between BARC (oxynitride) and resist was under the control of thickness, refractive index, and absorption coefficient. The refractive index and absorption coefficient were investigated by a function of the SiH_4/N_2O gas flow rate, which is the main control factor of the refractive index and absorption coefficient, in oxynitride deposition. Computational simulation was performed in order to obtain the reflectivity in the interface of BARC and resist with changes of the optical factors. The optimum thickness, refractive index, and absorption coefficient were obtained for the minumum reflectivity of oxynitride. The simulated results were sucessfully applied to the experiments, which was confirmed by the cross-sectional SEM. There is no standing wave in this optimum condition.

TF-ThP17 Ar/O_2 Plasma Treatment Effects on Structural, Optical and Electrical Properties of Sputtering-deposited CdS Thin Films, ***S.-H. Ryu***, *K.D. Myung, J.-S. Park,* Chosun University, Republic of Korea, *N.-H. Kim,* Chonnam National University, Republic of Korea, *W.-S. Lee*, Chosun University, Republic of Korea

CdS thin film has been widely used in the heterostructured solar cell applications as a window layer, which is a well-known n-typed semiconductor material. The sputtering method was employed for a large-area preparation of CdS thin film by the author in the previous study. It was

good quality and had the high transmittance through it. In this study, the sputtering-deposited CdS thin films were treated by the plasmas under the various conditions with some process parameters including RF power, gas flow rate and treatment time with Ar or O_2 gases. Surface morphology and structure of them were analyzed by AFM and XRD. The effects of each plasma treatment on the electrical and optical properties of CdS thin film were investigated by UV-Visible spectrophotometer and Hall effect measurement. The roles of morphology and structure of plasma-treated CdS thin films were compared by the optical and electrical characteristics. The improved cell parameters of CdTe / the plasma-treated CdS thin film solar cells, including short-circuit current density (J_{sc}), open-circuit voltage (V_{oc}), fill factor (FF), and efficiency, were also obtained at the condition for the good properties of the plasma-treated CdS thin film. Acknowledgement: This work was supported by National Research Foundation of Korea(NRF) grant funded by the Korean Government(MEST) (20 10-0016048).

TF-ThP18 Photodissolution and Photodiffusion Effects of Silver on Electrical Characteristics of CdTe Thin Film for CdTe/CdS Solar Cells, ***J.-S. Park***, *C.-H. Lim, S.-H. Ryu,* Chosun University, Republic of Korea, *N.-H. Kim,* Chonnam National University, Republic of Korea, *W.-S. Lee*, Chosun University, Republic of Korea

The maximum efficiency of CdTe/CdS solar cell was just 16.8% although the CdTe thin films shows the excellent absorbance above 99% with only about 2 μm of active thickness. The enhanced electrical characteristics of CdTe thin film are required for the improvement of the efficiency. Doping of polycrystalline CdTe thin film is thought to be one of the effective methods to control the conductivity of CdTe thin film. The group I elements including copper are generally known as substitutional acceptors in CdTe thin films, which increase the p-doping of CdTe thin films. However, there have been many reports on the degradation of solar cell by the high diffusivity of copper. In this study, silver was employed to dope the sputtering-deposited CdTe thin film. Silver was deposited on the 1 μm-thickness of CdTe thin film by the sputtering method with 10 nm-thickness. He-Ne laser (632.8 nm) was exposured with a small energy by a change of exposure time. The remained silver layer was removed with HNO_3+3HCl and H_2SO_4+H_2O_2 solutions. The photodissolution and photodiffusion effects of silver on the CdTe thin films were investigated by analyzing the electrical and optical properties of CdTe thin films including absorption coefficient, carrier mobility, resistivity and carrier density. AES depth profile was employed to examine the Ag-doped CdTe thin film with a change of He-Ne laser exposure time. Acknowledgement: This work was supported by National Research Foundation of Korea(NRF) grant funded by the Korean Government(MEST) (2010-0016048).

TF-ThP19 Surface and Interface Characterization of ALD and PVD Thin Films for Microelectronic Applications, ***L. Zhang***, *K.G. Lloyd, G. Blackman,* DuPont Corporate Center for Analytical Sciences, *J. Thompson,* DuPont CR&D, *L. Bao, J. Ryley,* DuPont Engineering, *D. Reardon,* DuPont CR&D, *M.A. Plummer, J.R. Marsh*, DuPont Corporate Center for Analytical Sciences

Surface and interface properties of thin films are critical for the growth and commercialization of microelectronics and Photovoltaics (PV) products. During the development of these thin film materials, chemical and structural characterization of surfaces at each film layer and interfaces between different layers are essential to aid product development and manufacture process for optimum products.

This presentation will focus on the applications of applying integrated methods/techniques to support thin film construction using Atomic Layer Deposition (ALD) and Physical Vapor Deposition (PVD) methods, including the study of surface composition and morphology, surface treatment, inter-layer diffusion, and film stoichiometry.

TF-ThP20 Enhancing of Optical Properties of TiO_2 Thin Films by N^+ Ion Beam Irradiation, ***H.A. Shukur***, *I. Takano*, Kogakuin University, Japan

Titanium dioxide (TiO_2) has considerable properties such as photocatalytic effect, dye-sensitized photovoltaic effect, photoinduced hydrophilicity and transparent electrod. Among all these properties photocatalytic property has been interested by many researchers because of its promised application such as antifouling effect and ability to decompose environmental pollution materials. However, TiO_2 has a high band gap (3.0 ~ 3.2 eV) so that the most photocatalytic effect occurs under UV irradiation. In order to improve TiO_2 behavior under visible light, there is many researchers have used various methods such as gas or metal doping.

In this study N^+ ion implantation was used to improve the optical properties of TiO_2 films, which were prepared by reactive magnetron sputtering on glass substrate (corning #1737). The substrate was sputtered by Ar ions in order to clean the surface before the TiO_2 thin film formation. Titanium (Ti) was sputtered from Ti target in an Ar / O_2 gas and the substrate was hated at 200 ºC. The total film thickness was around 145nm with a deposition rate of 0.025nm/sec. N^+ ion was irradiated to TiO_2 thin film at 15keV in acceleration voltage and 40μA/cm^2 in ion current density with a various irradiation doses from 2.5×10^{15} to 250×10^{15}ions/cm^2. Film thickness of the samples was measured by Avantes optical spectrometers system (AvaSpe-2048). The structure was determined by X-ray diffraction (XRD: MAC Science High quality XG M18XCE) with CuKα (0.154nm) radiation at an incident angle of 0.3º, and the composition was characterized by X-ray photoelectron spectroscopy. The photocataylitic property was measured by a methylene blue immersion test. The spectrophotometer (SHIMADZU UV-2550) was used to measure the difference in light absorption at a wave length of 665nm and also was used to measure the optical band gap for ion irradiated films.

N^+ ion implanted TiO_2 films showed a narrower optical band gap than unirradiation films, i.e. N^+ was substituted for O and created a new energy level. Optical band gap was changed from 3.58 to 3.5 eV at sample of 12.510^{15}ions/cm^2 ion irradiation dose, this sample was showed a maximum photocatalytic activity for visible light.

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We propose the addition of fluorine in SnO_2 to increase n-type doping be used as transparent electrode in photovoltaic heterostructure. The thin films were deposited on glass substrates (at different temperatures) by RF magnetron sputtering using a SnO_2:F target employing an argon atmosphere. The thin films were thermal annealed using a nitrogen flux. We present results of the structural and chemical characterization obtained through X-ray diffraction, atomic force microscopy (AFM), scanning electron microscopy (SEM) and energy dispersive X-ray microanalysis (EDX). The electrical, optical and structural properties were determined before and after heat treatment; the results are discuss in terms of growth details.

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