Thin Films
Room Naupaka Salon 1-3 - Session TF-WeP
Thin Films Poster Session

TF-WeP-1 Fabricating Optical Coatings on Complex Surface Using Atomic Layer Deposition*, Liangge Xu,* Harbin Institute of Technology, China

The unique layer-by-layer growth mechanism of atomic layer deposition (ALD) enables exceptional uniformity, conformality, and accurate film thickness control for many thin films. To date, ALD has been limited to relatively small-sized substrates. In optical systems, these properties are of utmost importance as sustaining optical performance requires not only a high degree of uniformity (large size substrates) but also excellent conformality when it comes to complex micro-or macrostructures (Complex shape substrates). For the traditional physical vapor deposition, to reach a high level of uniformity and conformality on domes, need to design specialized motion structures. This comes with an extensive load of mechanical work and process optimization, ultimately leading to tight control of the process parameters, even it the results may not be ideal. In this work, A new ALD tool has been designed, constructed, and tested to apply uniform protective coatings in a deposition dome with over 0.2 m diameters. We have named it as conformal ALD system (CAS), which employs a unique chamber design, and our design approach is adapted to any size of hemispherical dome and dome with Von Karman curves. To demonstrate our idea, we have used a hemispherical dome holder (radius = 100 mm), deposited on the inner side by depositing Al2O3 films, and on the outer side by depositing Ta2O5 films. Measuring their thickness distribution at the typical position of the dome, we have been able to achieve a revolutionary change in the range of non-uniformity, that is, to achieve non-uniformities close to 1 % over the entire structure.

TF-WeP-2 Gas Encapsulating Layer for Stretchable Electronics by Selective Infiltration of Al_2O_3 in Polymer Films*, Sangho Cho,* Korea Institute of Science and Technology, Republic of Korea

Atomic layer infiltration (ALI) has been performed for the preparation of the Al_2O_3-polymer hybrid layer as thin gas barrier films. Filling of the free volumes of polymers at the subsurface region with Al_2O_3 resulted in an excellent water vapor transmission rate (WVTR) low enough to be used as gas encapsulating films for display applications. Among various polymeric substrates, PET, PI, and Nylon 6 formed hybrid thins layers with the infiltration depth in the nanometer ranges while Al_2O_3 could not infiltrate into PFA and PS films. The selectivity of Al_2O_3 infiltration into polymer films was employed to prepare stretchable gas encapsulating films by encapsulating individual segments of 144 Ca dots by Al_2O_3-PET hybrid films on a PFA polymer substrate. Regardless of bending and stretching, it exhibited extremely low gas barrier properties with WVTR of $<10^{-7}$ $gm^{-2}day^{-1}$. This strategy would be a promising way of hermetic sealing in the stretchable electronic system.

TF-WeP-3 Background Removal Limitations on Absolute Accuracy in XPS of Homogeneous Materials*, C. Richard Brundle,* C. R. Brundle and Associates*; B. Crist,* The XPS Library*; P. Bagus,* University of North Texas

The precision achievable in XPS is very good. Accurate quantitation from relative peak intensities is more difficult (1). Normalizations for photoionization cross-sections, σ, and variation of analysis depths, λ, are required, but the procedures are well understood. Separation of the intrinsic photoelectron spectrum from its associated scattered electron background is on less secure ground, as there are several approaches, and implementation requires using the software of the instrument vendor or commercial analysis package vendor. The situation is most difficult when an XPS core level "peak" consists of strong overlapping structure spread over a wide BE range, such as with Fe 2p and O1s in Fe_2O_3 (2). We have examined, for a single crystal sample, the implementation of different background removal procedures: Tougaard (U2 version), T, Shirley, S, Linear, and total signal. The choice of the high BE endpoint, implying there is no further intrinsic signal beyond that BE, is most important. It is possible to adjust endpoints to return the "expected" answer, 40% atomic Fe, but this is somewhat arbitrary, and assumes 100% accuracy of the relative σ's, and relative λ's, in addition to assuming a) that the Transmission Function of the instrument is correct and b) for our particular case here (and much of the prior literature!), that a small signal from OH is properly accounted for in the analysis. The best consistency is obtained by a compromise between a wide enough range (start to end points) of background removal to include all observable substructure associated with Fe 2p and with O1s, while keeping the BE range very similar for Fe2p and O1s. If such a situation is achievable, there is only a small difference between using T, or S, backgrounds. Even a linear background, or no removal at all, will return values within 10% of the T or S derived Fe %age values. The reason for the close agreement of T and S compositions, despite the huge difference in the amounts of backgrounds removed, is that *the background is proportional to the signal generating it*, so provided the same removal procedure is adopted for both Fe2p and O1s, the functional form of the removal is of secondary importance. It is important to note that the analyst should **never** pick ranges where substructure is included for one of the elements, but not the other.

References

1. C. R. Brundle and B. V. Crist, J. Vac. Sci. Tech A, 38(4) Jul/Aug 2020; doi:10.1116/1.5143897
2. P. S. Bagus, C. J. Nelin, C. R. Brundle, B. V. Crist, N. Lahiri, and K. M. Rosso, Phys. Chem. Chem. Phys., 2022, **24**, 4562-4575.

TF-WeP-4 Electrical Properties of Metal-dual Insulator Type Buried Channel Array Transistor*, INKYUM lee,* Sungkyunkwan University, Korea

In this study, we suggest channel array transistor (BCAT) structure with dual insulator(HfO_2 and SiO_2) to solve short channel effect(SCE) in the cells of dynamic random-access memory (DRAM) using 2D TCAD simulations BCAT is widely used to make high performance sub 30nm DRAM cell transistors. However, as the device size becomes smaller, device characteristics deteriorate due to SCE. We changed the single insulator currently used for BCAT to dual insulator to improve SCE characteristics. The electrical properties were analyzed according to the thickness changes of HfO_2 and SiO_2 while the total thickness of the insulator is equal. As a result, the higher the HfO_2 layer ratio, the better the value of Threshold voltage, Drain induced barrier lower (DIBL), body effect and swing, 25.2%, 39.8%, 20.9% and 7.0% respectively. HfO_2 with Highly dielectric permittivity would have increased electronic polarization in the insulator and reduced changes by external stress other than gate voltage. Finally, we also discuss disadvantages such as the insulator breakdown to suggest optimal device design scheme in terms of insulator.

TF-WeP-5 Effects of Ga Doping on the Optical Properties of Tetrahedral Amorphous Carbon Coatings Synthesized by FCVA & Sputter Hybrid PVD Process*, HoeKun Kim,* Korea Aerospace University, Republic of Korea*; J. Kim,* University of Incheon, Republic of Korea*; S. Lee,* Korea Aerospace University, Republic of Korea

For the decade, it has been shown that diamond-like carbon (DLC) coatings are very promising anti-reflection (AR) and protective coatings for optical device application. The advantages of DLC include high chemical stability, radiation stability and high hardness with the possibility of changing their optical properties by varying the deposition conditions. Especially, tetrahedral amorphous carbon (ta-C) coatings with extremely high hardness, smooth surface, excellent wear resistance, and better thermal stability than DLC have been paid much attention to an alternative protective coating materials. Additionally, optical properties of the ta-C coating could be improved by various metals doping. In this study, various contents of Ga were doped in the ta-C coating to improve the optical properties of the ta-C coatings. Filtered cathodic vacuum arc (FCVA) and sputter hybrid system was co-deposited to synthesize the metal doped ta-C coating. As the Ga doping content increased, surface morphology of ta-C coating changed to more rough and certain nipple arrayed, and surface roughness value increased to 118nm. In the ta-C coating with 8.9at% Ga, the Ga carbide phase was formed in carbon matrix, and this formation contributed lattice disorder and defects on surface.Raman spectroscopy analysis showed that all the coatings had high sp3/sp2 fraction over 56%, and the hardness showed high values of 48 GPa, and these values showed relatively high compared to other AR coating. 8.9at.% Ga doped ta-C coating showed high transmittance in the field of ultraviolet light about 92.4% compared to pure ta-C coating of 88%. This indicates that surface morphology change to nipple array influenced to minimized reflection over wide angles of incidence, and improve transmittance by reducing reflections.

Acknowledgement

This work has supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2021R1A2C1010058)

TF-WeP-6 Improved Leakage Currents of ALD ZrO_2 by Controlling Surface Reaction with Plasma Source, ***Il-Kwon Oh,*** Ajou University, Republic of Korea*; H. Kim,* Korea Electronics Technology Institute (KETI), Republic of Korea

The use of metal-organic precursors and low temperature growth conditions in the process of depositing oxides with ALD often results in incomplete decomposition of the precursors and residual concentrations of impurities. Since these impurities adversely affect electronic performance such as carrier trapping and fixed charge formation, reducing these impurities is an important issue. These impurity content could be removed by reaction between the precursors and reactants used during the process.

Metal oxide ALD processes are classified according to several oxidant, such as thermal ALD, PE-ALD, and O_3 ALD, each using reactants such as H_2O (or other oxidants), O_2 plasma, and O_3. We systematically and comparatively investigated thermal ALD and PE-ALD ZrO_2 using a widely used precursor of $CpZr(NMe_2)_3$. We observed that Zr-Cp and Zr-$N(CH_3)_2$ have different degrees of ligand exchange, which leads to different surface-reaction with reactants. The weak oxidizing power of H_2O showed difficulties on breaking the Zr-Cp bond, while the O_2 plasma reacts due to the high reactivity of oxygen radicals. The use of plasma reactant results in dramatic lowering the impurity level in the deposited ZrO_2 film, leading to superior film properties such as roughness (RMS 0.293 nm) and film density (5.8 g/cm^3). In contrast, the case of H_2O was observed not easy to break the Zr-Cp bond, leading to relatively low film quality. The difference in the density and impurity content of the film also affects the performance of the electrical device, such as dielectric constant, interface trap density, trapped oxide charges, and leakage currents (9.11 E-05 A). We believe this study will be useful to develop ALD ZrO_2 process with Cp-containing Zr precursor.

TF-WeP-7 High Performance Amorphous Oxide Semiconductor Thin-film Transistors with HfO_2/Al_2O_3 Gate Insulator Deposited by Low Temperature ALD, ***Se-Hyeong Lee**, S. Bak, C. Park, D. Baek, M. Yi,* Pusan National University, Republic of Korea

Amorphous oxide semiconductor (AOS) thin-film transistors (TFTs) have been extensively studied because of their applicability to next-generation display. Because SiO_2 exhibits excellent insulating properties and uniformity, the doped Si and thermally grown SiO_2 are generally used as a gate electrode and a gate insulator in the conventional AOS TFTs, respectively. However, the thermally grown SiO_2 cannot be used as the gate insulator in AOS TFTs of the next-generation display since they are required to be transparent in the visible light region and compatible to the flexible substrate.

Therefore, in this study, we fabricated indium-zinc oxide (IZO) TFTs with HfO_2/Al_2O_3 gate insulator deposited by low temperature atomic layer deposition (ALD). Because Al_2O_3, a representative high-k dielectric material, has a wide bandgap (~7.5 eV), low leakage current can be obtained when used for TFTs as a gate insulator. However, since Al diffusion into the channel layer occurs easily due to the small ionic radius of Al cations, an HfO_{-2} high-k dielectric layer was deposited as a buffer layer to reduce the defects at the channel-insulator interface. Also, the high-k dielectric insulator has the advantage of reducing power consumption by lowering the driving voltage of the fabricated TFTs.

Fig. 1 represents the cross-sectional schematic diagram of IZO TFTs with HfO_2/Al_2O_3 gate insulator. The Al_2O_3 gate insulator and HfO_2 insulator buffer were deposited on a heavily doped p-type Si substrate by low temperature ALD at 120 ℃ using tri-methyl-aluminum (TMA), tetrakis [ethyl-methyl-amino] hafnium (TEMAHf) and H_2Oas an Al precursor, a Hf precursor and an oxidant, respectively. The IZO channel layers and S/D electrodes of the fabricated TFTs were deposited by radio-frequency (RF) magnetron sputtering and thermal evaporator, respectively. The RF magnetron sputtering was conducted with IZO (In: Zn = 90 wt.%: 10wt.%) target in R.T. and 2.0 x 10^{-3} Torr. After depositing the channel layers, annealing was performed using a hot plate at 250 ℃ for 1h. The fabricated TFTs were analyzed with a semiconductor parameter analyzer (Elecs Co. EL423).

Fig. 2 shows (a) output curves and (b) transfer curves of IZO TFTs with HfO_2/Al_2O_3 gate insulator. The electrical properties of the fabricated TFTs exhibited 6.02 cm^2 / Vs of carrier mobility (μ_{sat}), 1.18 x 10^6 of on-off current ($I_{ON/OFF}$), 0.55 V of threshold voltage (V_{th}), and 0.31V/dec of subthreshold swing (SS). Afterward, to improve the electrical properties, we are due to optimize the IZO TFTs with HfO_2/Al_2O_3 gate insulator by varying the thickness of insulator, the thickness ratio of Al_2O_3 and HfO_2, and growth temperature, respectively.

TF-WeP-8 Advanced Surface Analysis of Very Thin Surface Coatings, ***MATJAŽ FINŠGAR,*** University of Maribor, Slovenia

Very thin surface coatings in the range of a few nanometers are very challenging to analyze. Identification and knowledge of the distribution of molecular species within these surface coatings are very important for the final performance of most materials. Such surface information can be obtained using advanced surface analysis techniques such as tandem (MS/MS) time-of-flight secondary ion mass spectrometry (ToF-SIMS), X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM), and 3D profilometry. In addition, the gas cluster ion beam (GCIB) sputter source provides new opportunities for the analysis of such thin organic coatings.

In this work, the analysis of very thin organic surface coatings is presented. These organic coatings formed (self-assembled) in a corrosive chloride solution on a brass surface. The molecular conformation was completed using tandem ToF-SIMS capability by describing the molecular fragmentation mechanisms of the various precursor ions. Moreover, organometallic complexes were identified on the surface, which formed between the metal ions released due to corrosion and the organic molecules. Such analyses are still very rare and new to the SIMS database in general. After obtaining the ToF-SIMS signals describing the molecule, 3D distribution analysis was performed using GCIB sputtering associated with 3D ToF–SIMS imaging. The chloride was found to be located below the coating, indicating that the formation of metal chlorides is faster than the adsorption of the organic molecules. The latter was also confirmed by the GCIB-XPS analyses using Ar cluster sputter beams at different acceleration energies and cluster sizes. Finally, surface topography and agglomeration of the molecules in the surface coating were demonstrated by AFM (smaller surfaces) and 3D profilometry (larger surfaces).

References

[1] FINŠGAR, Matjaž. Time-of-flight secondary ion mass spectrometry and X-ray photoelectron spectroscopy study of 2-phenylimidazole on brass. Rapid communications in mass spectrometry, 2021, vol. 35.

[2] FINŠGAR, Matjaž. The influence of the amino group in 3-amino-1,2,4-triazole corrosion inhibitor on the interface properties for brass studied by ToF-SIMS. Rapid communications in mass spectrometry, 2021, vol. 35.

[3] FINŠGAR, Matjaž. Advanced surface analysis using GCIB–C_{60}^{++}-tandem-ToF-SIMS and GCIB-XPS of 2-mercaptobenzimidazole corrosion inhibitor on brass. Microchemical journal, Volume 159, December 2020, 105495

TF-WeP-9 Temperature Dependence of Dielectric Function for WSe_2, *X. Nguyen,* ***Tae Jung Kim,*** Kyung Hee University, Republic of Korea*; V. Le, H. Nguyen,* Vietnam Academy of Science and Technology, Viet Nam*; Y. Kim,* Kyung Hee University, Republic of Korea

The transition metal dichalcogenides (TMDC) form a group of layered, highly anisotropic compounds which exhibit interesting and unusual physical properties. Among these TMDC materials, WSe_2 has been a subject of great interest. Besides common characteristics of TMDC family i.e., van der Waals layered structure, indirect-to-direct bandgap transition in the monolayer regime, and spin-valley coupling, WSe_2 also constitutes a high quantum yield in 2D system and can be synthesized on a large area by chemical vapor deposition, opening various potential applications. To meticulously design and understand 2D optoelectrical device's function correctly, the optical constants of monolayer WSe_2 are needed. Although there are a few studies on the dielectric functions, systematic study on temperature dependence of critical points (CPs) of monolayer WSe_2 has not been reported, yet. In this work, we report the dielectric function of monolayer WSe_2 from 0.74 to 6.42 eV at temperatures from 40 to 350 K using dual rotating compensators ellipsometry. The sample is a large area WSe_2 thin film grown on sapphire substrate by low pressure chemical vapor deposition. The sample's quality was confirmed by AFM, Raman, photoluminescence spectra, and spectroscopic ellipsometry. The CP energies were determined by standard lineshape analysis of numerically calculated second derivatives of ε with respect to energy. Several CPs are distinguished at low temperature where the CPs are blue shifted and sharpened as a result of the reduced lattice constant and electron-phonon interaction. Especially, by carefully examining the region from 1 to 2 eV, the existence of three peaks can be diagnosed, which can be identified by the combination of a neutral exciton *A*, a negatively charged exciton A^-, and a superposition of biexciton emission (*AA*) with defect-bound exciton emission (*L*1). The *B*-exciton structure also shows a significantly asymmetric lineshape, indicating contributions of at least two CP structures. These results will be useful for physical understanding and application for the device based on WSe_2.

TF-WeP-10 Surface-treated ZnO/Ag/ZnO Mesh Electrodes for High-efficiency Blue TADF OLEDs, ***Ho Jin Lee,*** *N. Kim,* Korea University, Republic of Korea*; W. Ren,* Korea University, China*; S. Hong, H. Kim, T. Kim,* Korea University, Republic of Korea

The demand of highly efficient and deformable flexible organic light-emitting diodes (FOLEDs) has recently increased drastically with the rapid advance of wearable devices. To develop a high-performance FOLEDs, the development of flexible transparent conductive electrodes (FTCEs) and emitting materials is essential. Mesh-structured electrodes are one of the promising FTCEs as substitute of indium tin oxide [1,2], owing to their excellent optoelectrical properties with highly deformable mechanical properties. Despite such remarkable properties, a few characteristics other than transmittance or deformability must be considered to practically use mesh electrodes for demonstration of high-performance FOLEDs [3]. One of the intrinsic problems is the bumpy surface of mesh pattern, which induces leakage current or charge accumulation. Yet, PEDOT:PSS or SU-8 are used for planarize the rough surface however, these layers are lack of conductivity, which increases the turn-on voltage of FOLEDs [4]. In addition to the rough surface issue, the work function mismatch between the FTCE and organic transport or injection layers deteriorate the charge injection efficiency.

In addition to the development of FTCEs, it is hard to get high-performance of FOLED without the development of emission layer. To date, thermally activated delayed fluorescence (TADF) emitters have shown improved device performance however, few research have been focused on verifying the stability of the materials.

Herein, high-performance and flexible blue TADF OLEDs are proposed using nickel (Ni)-doped zinc oxide (ZnO)/silver (Ag)/ZnO mesh (Ni:ZAZ) electrode and a boron-based TADF emitter. The Ni doping is conducted through co-sputtering process of ZnO and Ni dopants. As shown in Fig. 1, the Ni:ZAZ mesh electrode shows remarkably high optical transparency (>90%), and low sheet resistance (<10 Ω sq^{-1}), together with superior flexibility. Addtionally, the increase of work function (4.8 eV -> 5.1 eV) is observed via surface doping. Notably, the similar (or enhanced) optical and electrical property is observed after Ni doping, which indicates the effective penetration of Ni dopant to the surface of ZnO. The Ni:ZAZ mesh electrode is then applied as an anode of flexible OLEDs with no additional layers for planarization.

We also synthesized a boron-based deep blue TADF dopant material in powder for thermal evaporation system, and co-evaporated with the host material. As a result, the proposed FOLEDs exhibited superior device efficieny, which is attributed to the enhanced opto-electrical properties of Ni:ZAZ mesh electrode and highly efficient boron-based TADF emitter material.

TF-WeP-11 Low Power Consumption in Superlattice-Like NiOx/GeSb Multilayer Film for Phase Change Memory Application, ***Tae Ho Kim,*** *T. Kim, K. Yoo, H. Lee, S. Park, D. Kim, J. Choi, T. Kim,* Korea University, Republic of Korea

As computing technologies such as big data, artificial intelligence and machine learning develops, the development of memory device that stores and processes vast amounts of data is also required. From various performance of memory device, phase change memory (PCM) is the powerful candidate for next-generation memory. $Ge_2Sb_2Te_5$ (GST-225) based PCM has outstanding performance such as non-volatility, long write endurance and high inherent scalability with existing complementary metal-oxide-semiconductor process. Despite its advantages, the GST-225 based PCM is hindered by reliability such as low switching speed, low crystalline temperature, and resistance drift.

In this study, we propose GeSb-based phase change memory device that can obtain a fast switching speed, owing to the fragile Sb-Sb bond while excluding Te atoms that degrade repeatability of memory operations due to high vapor pressure and low melt point. In addition, we insert the NiOx layers on the GeSb layer to generate the thermal boundary resistance (TBR) at the interface of the GeSb layer and the NiOx layer. The superlattice-like NiOx/GeSb multilayer film has the higher crystallization temperature than the single layer of GeSb and suppresses heat dissipation by TBR to efficiently utilize the heat required for phase change in GeSb layer. The adding of NiOx can improve the stability of GeSb material and lower power consumption phase change memory devices. The results of the I-V sweep from PCM devices with different structures.The threshold voltage of the NiOx/GeSb superlattice PCM device is 1.6 V, which shows significantly lower power than the GeSb-based PCM device (~ 3.4 V). Consequently, NiOx/GeSb multilayer might show low power consumption behavior on pulse operations and thermal stability by inserting NiOx layers.

TF-WeP-12 Hydrothermally Deposited Biochar Coating on the Surface of a Plain Steel, ***Yong Gan,*** *C. Negrete,* California State Polytechnic University Pomona*; W. Hung, K. Anderson,* California State Polytechnic University, Pomona*; J. Gan,* University of California, Los Angeles*; C. Grice,* University of Toledo

Hydrothermally Deposited Biochar Coating on the Surface of a Plain Steel

Yong X. Gan [1,*], C.J. Negrete [1, 2], Wesley Hung [1], Kevin R. Anderson [1], Jeremy B. Gan [3], Corey R. Grice [4]

[1] Department of Mechanical Engineering, California State Polytechnic University, Pomona, 3801 W Temple Avenue, Pomona, CA 91768, USA.

[2] Citrus College, 1000 W Foothill Blvd, Glendora, CA 91741, USA.

[3] Department of Chemical and Biomolecular Engineering, The University of California, Los Angeles, 405 Hilgard Avenue, Los Angeles, CA 90095, USA.

[4] Center for Materials & Sensor Characterization, College of Engineering, The University of Toledo, 1700 N Westwood Ave, University of Toledo, Toledo, OH 43606-3390, USA

* Correspondence: Tel. +01-909-869-2388; Email: yxgan@cpp.edu (Y.X.Gan)

Abstract

In this work, a sugar-derived, hydrothermally carbonized biochar coating on an ANSI-1018 low carbon plain steel was prepared. First, hydrothermal carbonization of 10% sugar (sucrose) solution at 200°C and 1.35 MPa for 4 h was performed to generate a carbon rich biochar coating on the steel. Then microstructure and composition of the biochar coating were studied using scanning electron microscopy (SEM). The corrosion resistance of the steel with coating and without coating was evaluated by comparing the Tafel slopes of each sample measured in seawater. In addition, the corrosion current and the potential of corrosion were calculated to show the effect of the carbonized biochar coating on the corrosion behavior of multiple steel specimens. It was found that hydrothermal carbonization of sugar generated a dense carbon-rich biochar layer on the surface of the steel. This biochar layer is corrosion resistant as shown by the increase in the corrosion potential and the decrease in the corrosion current for the low carbon steel. This hydrothermally produced carbon layer is like a passivation coating on the steel to protect the steel from corrosion. The change in the seawater corrosion behavior of pure iron due to the existence of such a carbonized layer was also studied. The carbonized coating did not reduce the corrosion current obviously, but caused the positive shift in the corrosion potential. The integrity of the coating is thickness dependent. For thick coating, localized cracking was found and the exposure of the steel surface was observed under electron microscope. The cracking of the biochar coating resulted in the iron oxide formation on the surface of the steel in the ambient environment.

Key words: Hydrothermally carbonized biochar coating; low carbon steel; seawater corrosion resistance; corrosion potential; corrosion current; Tafel slope.

TF-WeP-13 Comparison of Continuous and Pulsed Low Power DC Sputtered Ti Thin Films, ***Anna Maria Reider,*** University of Innsbruck, Austria

In this work, titanium thin films with thicknesses up to 105 nm were deposited on borosilicate glass implementing low power continuous (25 W) and pulsed (85 W) DC magnetron sputtering. The characteristics of the resulting films were studied via atomic force microscopy (AFM), X-Ray Photoelectron Spectroscopy (XPS), VIS spectroscopy and four-point-probe measurements. For both the continuous and pulsed sputtering, the films exhibit a comparably low surface roughness with no visible column-and-void structure. Additionally, the films show overall high reflectivity and constant transmission and reflectance for wavelengths in the visible range of the spectrum. The electric resistivity could be measured even for film thicknesses down to the single nanometer range and approaches the bulk value for higher film thicknesses. The low power regime of magnetron sputter deposition does not only offer the possibility of studying the development of physical characteristics during the growth of ultra-thin films but also provides the advantage ofextremely low heat development and no mechanical force on the substrate during the coating process. This concept may hence be utilized in temperature-sensitive coating processes, such as the fabrication of conductive coatings on flexible antennas.

TF-WeP-14 Sputter-Deposited High Entropy Alloy Thin Film Electrocatalyst for Enhanced Oxygen Evolution Reaction Performance, ***Siang-Yun Li***, National Cheng Kung University (NCKU), Taiwan; *T. Nguyen,* National Cheng Kung University (NCKU), Taiwan, Viet Nam; *Y. Su, C. Lin, Y. Huang, Y. Shen, C. Liu, J. Ruan, K. Chang, J. Ting,* National Cheng Kung University (NCKU), Taiwan

Thin film catalyst, giving a different morphology, provides a significant advantage over catalyst particles for gas evolution reaction. Taking the advantages of sputter deposition, we hereby report high entropy alloy (HEA) thin film electrocatalyst for oxygen evolution reaction (OER). We investigate the catalyst characteristics not only in its as-deposited state but also during and after the OER. For comparison, unary, binary, ternary, and quaternary thin film catalysts were prepared and characterized. The surface electronic structure modification due the addition of a metal is studied experimentally and theoretically using density function theory calculation. We demonstrate that sputtered FeNiMoCrAl HEA thin film exhibits OER performance superior to all the reported HEA catalysts with robust electrocatalytic activity having a low overpotential of 220 mV at 10 mA cm^{-2}, and excellent electrochemical stability at different constant current densities of 10 and 100 mA cm^{-2} for 50 h. Furthermore, we have investigated the microstructure transformation during the OER, which is important for the understanding of the OER mechanism provided by HEA electrocatalyst. Such finding would contribute to future catalyst design.

TF-WeP-15 Fabrication of Antimicrobial and High Transparency TiO_2 Thin Films by Superimposed High Power Impulse and Medium Frequency Magnetron Sputtering, ***Bih-Show Lou,*** Chang Gung University, Taiwan; *W. Chen, J. Lee,* Ming Chi University of Technology, Taiwan, Republic of China; *W. Diyatmika,* Leibniz Institute of Surface Engineering, Germany; *J. Lu,* Ming Chi University of Technology, Taiwan, Republic of China; *C. Chang, P. Chen,* Institute of Nuclear Energy Research, Taiwan

Titanium dioxide thin film has been widely studied and applied because of its excellent photocatalytic, antimicrobial, and optical performance. The application of TiO_2 films as the antibacterial and transparent coatings deposited on touch screens and touch panels by sputtering methods for preventing the infection of microorganisms is required. The high power impulse magnetron sputtering (HiPIMS) technique is characterized by its ability to fabricate oxide thin films with dense microstructure and better film quality. In this work, critical processing parameters including, target poisoning ratio/oxygen gas flow rate, peak power density, substrate bias, substrate heating temperature, and gas pressure for achieving high antimicrobial ability, transparent and anatase rich TiO_2 films with more {001} facets by the superimposed HiPIMS and medium frequency (MF) magnetron sputtering techniques were discussed. This study explores the superimposed HiPIMS-MF deposition approach to produce the TiO_2 thin films, which exhibit good adhesion (> 30N critical load), high transmittance (>80%), and 100% antimicrobial ability in large-scale production.

TF-WeP-16 Annealing Effects of Multi-Layered Titanium Dioxide (Tio2) Thin Film by Sol-Gel Method, ***Moniruzzaman Syed***, *J. Gibson, D. White,* LeMoyne-Owen College

Titanium dioxide (TiO_2) multilayer thin films (2-layers) have been deposited on glass substrate by using Sol-Gel technique. TiO_2has anatase crystal structure and the grain size is increased when the annealing temperature have been increased, according to XRD results. Four point probe measures the electrical properties showed that the average resistivity is decreased with increasing the annealing temperature. Optical properties of the films were measured by 'UV–Vis spectroscopy which showed the high transmittance in the visible region. The optical band gap energies were found to be decreased with increasing annealing temperature. These properties showed that the multilayer films of TiO_2can be enhanced the properties of optoelectronic devices.

TF-WeP-17 Impact of Micron Structures, Substrates and Protective Covering on the Thermochromic Property of Vanadium Dioxide Grown by Magnetron Sputtering, ***Jazmyne Smith***, *A. Adedeji,* Elizabeth City State University

Vanadium dioxide is known for its optical and electrical switching characteristics at a transition temperature of about 68°C. Thin films of pure vanadium was deposited by DC magnetron sputtering on crystalline and amorphous quartz substrates and subsequently oxidized in N_2/O_2 ambient at 500°C for 4 hours at a pressure of 800 milli-torr. Microscopic structures (circles and stars) were defined by photolithography techniques before sputtering vanadium on some of the substrates. Transmittance of 160 nm thin films on quartz substrates jumped reversibly from about 35% to less than 5% at a wavelength of 1600 nm. The star and circular structured samples have higher transmittance but less change in transmittance at transition temperatures which are higher than for plain thin films. X-ray diffractometry, Scanning Electron Microscopy with Energy Dispersive and Atomic Force Microscopy are some of the techniques employed for surface characterization of the samples. Optical characteristics were determined with filmetrics equipment that measured both the transmittance and reflectance simultaneously in the range 200 – 1700 nm. Electrical transport characteristics of the plain films were determined with Ecopia Hall Effect measuring system.

TF-WeP-18 Topology Phase Diagram of Metal Oxides Nanoflake in Skyrmion-based Spintronic Devices, *D. Huang, Y. Lai,* Dept. Materials Sci & Eng., National Cheng Kung University,, Taiwan; *C. Kaun,* Research Center for Applied Sciences, Academia Sinica, Taiwan; ***Yen-Hsun Su***, Dept. Materials Sci & Eng., National Cheng Kung University,, Taiwan

Half century ago, a kind of quasi-particle is observed from the surface of magnetic material. Such topologically protected quasi-particle, skyrmion, is known to produce via spintronic in various magnetic materials. Skyrmion with wide applicability has unique properties in many fields, including particle physics and optoelectronics devices and so on. These special properties allow skyrmion to exist in the interface of devices with ultralow accumulation rate and high transportation rate. However, types of skyrmion and magnetic domain wall such as Néel-type skyrmion, Blöch-type skyrmion and multiple wormhole domain wall which modulated by parameters of Dzyaloshinskii-Moriya interaction (DMI), saturation magnetization, and stiffness coefficient are elusive and unexplored. The most important thing is building the phase diagram of skyrmion from featured parameters for modulating the appearance of skyrmion by presenting magnetization vortex. Here, we calculate the parameters of skyrmion to estimate and plot out the phase diagram of skyrmion in fine scale for precisely predict the type of skyrmion and the vortex of magnetization by Object Oriented Micro Magnetic Framework (OOMMF). We classify the different kinds of magnetic domain wall by the skyrmion number N, which is calculated by Python. Skyrmion creates a stable and high capacity in the applications of storage devices. The skyrmion crystals with nanoscale are much smaller than the traditional magnetic crystals created by lithography techniques. After getting the skyrmion phase diagram, the shapes, and states of the skyrmion can be changed by adjusting the parameters easily. Different shapes of the skyrmion also be used in very mini-size logic devices since the size of skyrmion allows to carry higher information density in skyrmion-based spintronic devices.

Author Index

Bold page numbers indicate presenter