Hard Coatings and Vapor Deposition Technologies
Room Golden West - Session B1-1-MoM

PVD Coatings and Technologies I

Moderators: Frank Kaulfuss, Fraunhofer Institute for Material and Beam Technology (IWS), **Jyh-Ming Ting**, National Cheng Kung University, **Qi Yang**, National Research Council of Canada

10:40am **B1-1-MoM-3 Structural, Optical and Wettability Properties of Thermally Evaporated CaF_2, MgF_2 and CaF_2/MgF_2 Films*, Ravish Kumar Jain, J Kaur, A Khanna,*** Guru Nanak Dev University Amritsar India, India

In this work, thin films of CaF_2, MgF_2 and their multilayered stacks have been deposited on microscopy glass substrates by thermal evaporation and their structural, optical and wettability properties have been studied. Four different sets of samples i.e. glass/CaF_2, glass/MgF_2, glass/CaF_2/MgF_2 and glass/CaF_2/MgF_2/CaF_2/MgF_2 were prepared. X-ray diffraction studies revealed that crystalline CaF_2 film grows in glass/CaF_2 and in the 2-layer stacked glass/CaF_2/MgF_2 samples whereas, it grows in the amorphous phase in 4-layered stacked glass/CaF_2/MgF_2/CaF_2/MgF_2 sample. On the other hand, MgF_2 layer in all the samples grows in the amorphous phase. Field emission scanning electron microscopy (FESEM) was used to study the surface morphology and thicknesses of the samples. The surface FESEM image of CaF_2 film shows very small flake-like morphology whereas the MgF_2 film has a smooth morphology due to its amorphous nature. The cross-sectional FESEM images found that the thickness of the pure CaF_2 film (102 nm) is lesser than that of pure MgF_2 film (127 nm). The optical transmittance and reflectance properties were studied by UV-Vis spectroscopy which confirmed that all the films possess good anti-reflecting properties. The average specular reflectance values in the wavelength range: 350-1100 nm are 10.8%, 7.9%, 8.6%, 6.4% and 8.4% for bare glass slide, MgF_2, CaF_2, 2-layer and 4-layer stacked films respectively which confirms that the reflectance decreases with the top coating of the fluoride films. The water contact angle studies were carried out to study the wettability properties of the samples and it is found that the pure $CaF_2$and MgF_2 films are hydrophobic with an average water contact angle 131±1° and 98±1°, respectively. The wettability properties of the 2-layer and 4-layer stacked structures were found to be completely different compared to single layer thin films and showed hydrophilic nature with water contact angles of 20±1° and 47±1° respectively with reflectance values that were comparable to those of MgF_2 and CaF_2 films. It is concluded that CaF_2 films have a very good potential to be used as hydrophobic anti-reflecting coatings and stacking with other well known optical material such as MgF_2, can tailor its wettability and anti-reflecting properties.

11:00am **B1-1-MoM-4 Metal / ScAlN / Interdigital Transducer (IDT)/ $LiNbO_3$ Multilayer Structure for High K^2 Surface Acoustic Wave Device*, Yu Hsuan Huang,*** National Cheng Kung University, Taiwan*; S Wu,* Tung-Fang Design University, Taiwan*; J Huang,* National Cheng Kung University, Taiwan

We reported a high electromechanical coupling coefficient (K^2) Surface acoustic wave (SAW) devices on metal / ScAlN/interdigital transducer (IDT)/ $LiNbO_3$ structure and we used Al/ Ti / Mo as metal layer. The $Sc_{0.31}Al_{0.69}N$ films in different thickness (0.5, 1, 1.5, 2 μm) were deposited on Y-128˚ lithium niobate ($LiNbO_3$) substrate which possesses high K^2 by reactive magnetron co-sputtering using Sc and Al as targets. In the previous research, the replacement of Al by Sc increases piezoelectricity because of the phase transition. The $Sc_xAl_{1-x}N$ films 2D-XRD result showed that high c-axis (002) orientation and 2D-XRD χ angle showed that there is a critical thickness. The (002) plane tilting from a normal direction of $LiNbO_3$ substrate before 1μm and it growth normal direction after critical thickness. The SEM cross-section result showed that ScAlN films have tilting form substrate and have columnar structures. The SEM top view indicated that spindle-like morphology and grain cover the whole surface when thickness over 1μm. The piezoelectric coefficient (d_{33}) measured the highest value 42.8 pm/V of $Sc_{0.31}Al_{0.69}N$ film. The K^2 values are increasing with the metal layer deposited on. The highest K^2 value is three time larger than IDT/ $LiNbO_3$ (4.9%) structure. The metal / ScAlN/ IDT/ $LiNbO_3$ structure have a great potential in high frequency and high K^2 SAW devices.

11:20am **B1-1-MoM-5 Sputter Deposited W-HfO_2 for Solar Absorbers*, Lih-Yang Chiu,*** *J Ting,* National Cheng Kung University, Taiwan

Tungsten-doped Hafnium oxide W-HfO_2) coatings were deposited using RF and DC reactive magnetron sputtering techniques. Stainless steel (.5 x .5 cm) was used as substrates for solar absorberW-HfO_2 coatings. In this works, various deposition parameters including sputtering power, O_2 flow rate, and deposited time were investigated. The resulting coatings therefore exhibit various compositions, crystal structures, grain sizes, and thicknesses. The obtained coatings were examined using field emission scanning electron microscopes, X-Ray diffraction, X-Ray photoelectron spectroscopy, Colorimeter technique (CIELab 1976 color space), UV/vis/NIR spectrometer, and Fourier-transform infrared spectroscopy. Effects of the material characteristics on the coating performance is discussed.

Keywords: W-HfO_2, reactive magnetron sputter, solar selective coatings.

11:40am **B1-1-MoM-6 High Power Impulse Magnetron Sputtering using Deep Oscillatory Micro Pulses for Surface Engineering*, Jianliang Lin,*** Southwest Research Institute, USA **INVITED**

As one version of high power impulse magnetron sputtering (HiPIMS) technique, deep oscillation magnetron sputtering (DOMS) is developed from the early modulated pulsed power magnetron sputtering (MPPMS) technique. In DOMS, large oscillatory high power micro-pulses (e.g. tens of μs) are generated within long modulation pulses (up to 3~5 ms). The magnitude of the peak power can be adjusted by controlling the on and off times of the oscillatory micro-pulses. By using optimal combinations of on and off times of these oscillatory micro-pulses, virtually arc free reactive HiPIMS process can be achieved for many insulating coating materials (e.g. Al_2O_3, AlN, SiO_2, etc.). The paper presents an introduction of the DOMS technique with key processing features and parameters. The observation and mechanisms of generating arc-free discharge for reactive sputtering insulating coatings using deep oscillatory micro-pulses will be discussed . Recent technological development in DOMS for surface engineering will be presented. Specific examples will be focused on high rate deposition of transparent metal oxide coatings for optical and wear resistant applications, super hard hydrogen free diamond like carbon (DLC) coatings for low friction and wear applications, strongly (0002) textured AlN films for piezoelectric applications, and thick superlattice nitride coatings for solid particle erosion and high temperature wear protection. It is shown that the enhanced target ionization in combination with excellent process stability in DOMS enables the deposition of a variety of high quality coating materials with improved properties.

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