Tuesday Afternoon Poster Sessions

Thin Films
Room: Exhibit Hall B2 - Session TF-TuP

Poster Session

TF-TuP1 Origin of Crystalline Quality Deterioration in Epitaxial Growth of CeO_2 Layers on Si Substrates, ***T. Inoue***, *S. Shida, H. Takakura, K. Takahashi, A. Horikawa, N. Sakamoto, M. Ohashi*, Iwaki Meisei University, Japan

Cerium dioxide (CeO_2) is a promising high K insulating material for microelecronic applications with chemical and mechanical stability. It is known that epitaxial CeO_2(110) layers grow on Si(100) substrates with a long range lattice ordering. It is reported that crystalline quality of the epitaxial layers varies from poly-crystalline to single-crystalline, in the vicinity of the critical temperature of the epitaxial growth. This is thought to be due to nucleus generation mode variation depending on surface asperity, contamination from the growth atmosphere and so on. In order to clarify the origin of the crystalline quality deterioration, it is strongly desired that the direct observation and structural analysis of the surface of epitaxial layers and the interface between the epitaxial layer and the substrate. This paper describes the results of microscopic analyses. AFM analyses indicate that there are three kinds of facets at the CeO_2 layer surfaces: gable roof shaped CeO_2(110) facets having excellent crystallinity, irregular shaped CeO_2(110) hillocks having poor crystallinity and tetrahedral hillocks with (111)-orientation. Cross-sectional TEM observations clarify that the shape and crystallographic structure of the irregular hillocks, whose increase in surface density leads to the deterioration of the epitaxial layer.

TF-TuP2 Structural and Electrical Characteristics of ZrO_2 as a Gate Dielectric and Buffer Layer Grown by RF Magnetron Sputtering, ***G.S. Lim***, *H.S. Choi, J.H. Lee*, Korea University, *Y.T. Kim, S.I. Kim*, Korea Institute of Science and Technology, *I.H. Choi*, Korea University

The zirconium oxide (ZrO_2) layer has been reported to have a relatively high dielectric constant and a strong barrier property against diffusion. Therefore, the buffer layer combined with SiO_2 is expected to have a good interface with silicon and a strong barrier property against interdiffusion. The emphasis of the results is twofold: the first is the high quality of the investigated films as evidenced by the small measured values of loss factor, flatband voltages, and surface states density as well as the low dispersion of the relative dielectric constants. This work examines the structural and electrical properties of ZrO_2 thin films deposited by rf magnetron sputtering using a Zr target. The ZrO_2 /$ZrSi_xO_y$ /SiO_2 layer is stoichiometric, uniform, amorphous, and has an equivalent oxide thickness of ~1 nm and a dielectric constant range from 15 to 18 depending upon process conditions and very small C-V hysteresis and low leakage current. The second is that Metal-ferroelectric-insulator-semiconductor (MFIS) structures using zirconium oxide (ZrO_2) layers as an insulating barrier against interdiffusion have been investigated. Strong barrier effect of ZrO_2 layer is demonstrated by both High-resolution transmission electron microscopy (HRTEM) and analysis of Auger Electron Spectroscopy (AES). Coercive field that decisively affects the memory window becomes greater by inserting the ZrO_2 buffer layer between ferroelectric thin film and silicon substrate and thus the memory window also increases with an electric field to the $SrBi_2Nb_2O_9$ (SBN). The memory windows of the MFIS structure were in the range of 0.7 ~ 3.6 V for gate voltages form 3 to 9 V. The maximum memory window was observed in the MFIS with a 12-nm-thick ZrO_2 layer. And the leakage current density was 4.74×10^{-8} A/cm^2 at an applied voltage of 3 V.

TF-TuP3 Structural Dependence of Magneto-optical and Optical Properties of Mn-Fe Alloys Films, ***J.B. Kim***, Hanyang University, Korea, *Y.V. Kudryavtsev*, Institute of Metal Physics, Ukraine, *R. Gontarz*, Hanyang University, Korea, *J.Y. Rhee*, Hoseo University, Korea, *Y.P. Lee*, Hanyang University, Korea

The structural dependence of the magneto-optical [equatorial Kerr effect (EKE)] and optical [optical conductivity (OC)] properties of the $Mn_{1-x}Fe_x$ alloy films have been investigated. $Mn_{1-x}Fe_x$ ($0 < x < 1$) alloy films were prepared by face-to-face DC sputtering onto glass substrates kept at 293 K. The x-ray diffraction study shows a bcc structure for the $Mn_{1-x}Fe_x$ alloy films with $x > 0.9$, a mixture of the fcc (γ-phase) and bcc (α-Fe phase) structure for $0.65 < x < 0.8$, and a fcc-like structure (γ-phase and α-Mn) for $x < 0.65$. It was shown that the EKE signal at 293 K for the $Mn_{1-x}Fe_x$ alloy films can be observed only for $x > 0.50$. All the EKE spectra have nearly the same spectral shape (Fe-like) and differ from each other only in the intensity. The observed experimental EKE spectra for the Fe-rich $Mn_{1-x}Fe_x$ alloys can be nicely described by the simulated ones made in the framework of the effective medium approximation on the suppositions of nonmagnetic γ-phase and that the boundary between pure γ-Fe phase and a mixture of γ- + α-Fe phases follows the phase diagram for bulk Mn-Fe alloys. The optical properties of all the investigated alloys can be separated into three groups which are related to the different crystalline structures of alloys: the OC spectra for the $Mn_{1-x}Fe_x$ alloys which contains α-Fe phase ($x > 0.65$-0.70) exhibit a noticeable interband absorption peak located at about 2.4 eV; such a peak is completely absent in the γ-phase based alloys; and the α-Mn based alloys reveal a significant interband absorption peak near 1.4 -1.5 eV.

TF-TuP4 Effects of Deposition Parameters and Physical Properties of Thin Films on Gas Sensing Characteristics, ***I. Hotovy***, Slovak University of Technology Bratislava, Slovakia, *J. Huran*, Slovak Academy of Sciences Bratislava, Slovakia, *J. Liday*, Slovak University of Technology Bratislava, Slovakia, *L. Spiess*, Technical University of Ilmenau, Germany, *P. Siciliano*, IME-CNR Lecce, Italy

Our research has been focused on the preparation and characterization of NiO thin films deposited by reactive magnetron sputtering. Small gas sensors on alumina substrate with different NiO thin films were fabricated and then were investigated their physical and sensing properties for application to nitrogen oxide. In order to apply NiO thin films to the nitrogen oxide gas sensor, NiO thin films (2000 Å) were prepared by dc reactive magnetron sputtering from a nickel metal target in an Ar@+@O_2 mixed atmosphere in two sputtering modes. Details about the deposition of NiO have been reported in previous papers.[1] The oxygen content in the gas mixture varied from 20 to 60 %. The films deposited in the metal-sputtering mode resulted in a polycrystalline (fcc) NiO phase with nearly stoichiometric composition. On the contrary, the films prepared in the oxide-sputtering mode were amorphous and oxygen rich. The post-annealing (500°C) of as-deposited NiO thin films changes amorphous to the (fcc) NiO phase for samples prepared in oxide-sputtering mode. TEM observations revealed a dense fine-grained structure with the grain size in the range 40-100 Å. AFM showed that the surface morphology NiO films could be modified by the process parameters as the oxygen content and the pumping speed. SEM observation and EDX analyses revealed uniform morphology and homogenous dispersion of NiO, Pt and Al_2O_3 phases. The depth distribution of elements (Ni and O) in the NiO thin films was measured by AES. We have investigated the sensitivity (I_g/I_0) versus operating temperature of NiO films when a concentration varied from 1 to 10 ppm of NO_2.

[1] Hotovy, I., Huran, J., Spiess, L., Hascik, S.: Sensors & Actuators B 57 (1999) 147-152.

TF-TuP5 Control of Epitaxial Film Growth of CuO and Cu_2O by Reactive-dc Magnetron Sputtering on Cu Target Kept in UHV Prior to Each Sputtering, ***I. Takahiro***, *M. Kunisuke*, Yokohama City University, Japan

The CuO and Cu_2O films were deposited on air-cleaved MgO(001) substrate by reactive dc-magnetron sputtering. The metallic Cu target was kept in UHV prior to each sputtering to avoid it's target poisoning. We determined the films structure and their orientation by reflection high-energy electron diffraction (RHEED) and X-ray diffraction (XRD). Before film deposition, it took 10 minutes for presputtering to clean the target surface. When presputtering was carried out in the Ar plasma at 10 mTorr, the CuO(111) // MgO(001) film was grown by sputtering in Ar (7 mTorr) and O_2 (3 mTorr) mixture plasma. On the other hand, the Cu_2O film was grown at the presputtering with Ar (7 mTorr) and O_2 (3mTorr) mixture plasma, where a few Cu regions were coexisted in it. The Cu_2O film had the following orientations: Cu_2O(001) // MgO(001), Cu_2O(110) // MgO(001) and Cu_2O(111) // MgO(001). These results indicate that the presputtering process is also an important factor in our system, which is probably associated with the shutter position inserted between substrate and target in presuputtering in our study. Then we have to consider about the shutter positioning effect for the presputtering. We also confirmed that the CuO and Cu_2O films are easily grown by exposing Cu film to O_2 gas at 10 mTorr. Therefore we have to discuss the thin film growth of CuO and Cu_2O from the viewpoint of the structure formation due to the condensation of the sputtered species and the oxidation of Cu film. We will make clear these effects on CuO and Cu_2O growth.

TF-TuP6 Preparation of Fe and Fe-N Thin Films using RF Magnetron Sputtering with Multipolar Magnetic Plasma Confinement, ***K. Kawai***, *H. Harada, K. Kawabata*, Hiroshima Institute of Technology, Japan

Thin films of αFe or alloys are suitable and widely used as media materials. Among them, Fe and Fe-N thin films are promising candidates as materials for thin film heads used in magnetic recording devices because of their saturation magnetization characteristics. However, the efficient preparation

of ferromagnetic thin films at a low gas pressure for a conventional planar magnetron sputtering with a thick target of magnetic materials is difficult because of the lower magnetic field above the target. We previously developed an unbalanced magnetron sputtering with a multipolar magnetic plasma confinement(MMPC) to prepare ferromagnetic thin films. The thin films of Fe and Fe-N were prepared on 7059glass substrates by the RF (13.56MHz) magnetron sputtering technique with MMPC, employing an Fe target(100mmϕ,5mm thick). Fe films were prepared at the RF powers of 100-200W and argon pressure down to $6.7x10^{-1}$Pa. It is shown that the deposition rate of Fe films linearly increases from about 4 to 12 nm/min, whose values are three times that of a conventional magnetron sputtering system. Fe-N films were also deposited by the same sputtering system in an Ar-N_2 gas mixture at different total gas pressures of $6.7x10^{-1}$-$8.0x10^{-2}$Pa and the gas flow ratio(N_2/Ar+N_2) of 0.1-0.6,where an RF power was kept at 150W. The electrical resistivity for reactively sputtered Fe-N films was significantly decreased from 300 to 90μmΩcm by lowering the total gas pressure to $8.0x10^{-2}$Pa. Compositional ratios were obtained in the range of 0-0.3 with increasing gas flow ratio of N_2 by XPS. The intensity of the Fe_3N line is observed by an XRD pattern of the Fe-N films deposited at $8x10^{-2}$Pa. These results demonstrated that this method is useful for fabricating high quality Fe-N thin films. Thus, this sputtering system is expected to greatly improve the efficient fabrication of high quality Fe and Fe-N thin films.

TF-TuP7 Mass and Optical Spectroscopy during Super-high Rate Ni Deposition by an rf-dc Coupled Magnetron Sputtering System with Multipolar Magnetic Plasma Confinement, ***M. Ohnishi***, *K. Kumabuchi, Y. Yamagata, K. Kawabata,* Hiroshima Institute of Technology, Japan, *H. Kajioka*, Industrial Research Institute Hiroshima Prefecture West, Japan

Magnetron sputtering systems offer an attractive alternative to electroplating fabricating techniques for films. Unfortunately, a high rate sputtering system for ferromagnetic films by conventional magnetron sputtering with a thick target of magnetic materials is difficult, because of the lower magnetic field above the target. An rf-dc coupled magnetron sputtering system with multipolar magnets around a Ni target (200mmϕ, 8mm thick) has been designed and tested for super-high rate Ni deposition. The deposition rate of the Ni films linearly increases with increasing dc power at an rf power of 50W and an Ar gas pressure of 0.5Pa and reaches the highest value of about 1.1μmm/min at a dc power of 20kW and at a distance of 120mm from the target surface. We measured simultaneously the ion energy distribution and optical emission spectra during high rate deposition for Ni films by an energy-resolved mass spectrometer PPM-422 (Balzers) whose orifice was set in front of the sputtering target at a distance of 260mm and by an optical emission spectrometer (OES), respectively. As the dc power increases, the peak energy of Ar^+ ion spectra shifts to a lower energy of a few eV from about 22eV and also that of Ni^+ ion spectra shifts to a lower energy of a few eV from about 12eV. The behavior in the energy of Ar^+ and Ni^+ ions in this experiment may be attributed to the plasma quenching induced by the increase in the number of sputtered Ni atoms in the plasma region. The experimental results show that the intensity of both the Ni^+ and Ar^+ ion spectra increases with increasing dc power, and the intensity ratio of Ni^+ to Ar^+ ions is more than 0.1 during high rate deposition. It is also observed from the OES results that the intensity of Ni^+ ion lines and Ni-neutral atom lines increases with increasing dc power, and is significantly higher than that of Ar^+ ion lines and Ar-neutral atom lines.

TF-TuP8 Large Remanent Polarization of Cerium-modified Bismuth Titanate Thin Films for Nonvolatile Ferroelectric Random Access Memory, ***K.T. Kim***, *C.I. Kim, D.H. Kang, I.W. Shim,* Chung-Ang University, Korea

The bismuth layer-structured ferroelectrics (BLSFs) are attractive lead-free material for ferroelectric random access memory (FeRAM) application because of its relative fatigue free character. However, BLSFs thin films have a disadvantage for high density integration in FeRAM in that they have a low remanent polarization. The ferroelectric properties, the crystal structure, and the microstructure of $Bi_4Ti_3O_{12}$ (BIT) thin films are influenced by the substitution of different sized ions in these bismuth layer-structured compounds. We investigated on the fabrication of cerium - substitution in BIT thin films using the MOD method, and on the effect of Ce-substitution in BIT thin films on the ferroelectric properties, such as the remanent polarization, fatigue, and retention characteristics. The incorporation of Ce into BIT results in a large 2Pr value, which is much larger than that of $SrBi_2Ta_2O_9$ (SBT) and $Bi_{4-x}La_xTi_3O_{12}$ (BLT) thin films at an applied voltage of 10 V.

TF-TuP9 Analysis of Stresses in Ru Thin Films Deposited by MOCVD, ***H.J. Lim***, *S.Y. Kang, C.S. Hwang, H.J. Kim,* Seoul National University, Korea

Ru is the most promising material for the capacitor electrode in the next generation DRAMs. Ru thin films, however, which are deposited by chemical vapor deposition have high tensile stresses. So many problems in respect of device reliability such as peeling or thermal deformation have been reported. In this study, we investigated the effects of the various deposition parameters on the stress behavior. Ru thin films were prepared by MOCVD on Si substrate using RuCp(i-PrCp) precursor and O_2 reaction gas. The stresses of films were measured using laser scanning method. The tensile stress increased with reduction of substrate temperature. And in thicker films, larger tensile stress appeared. These tendencies are attributed to low atomic mobility of the Ru material(T_m=2523K). Also tensile stress increased after annealing. It can be explained by volume shrinkage through rearrangement of grain boundary having less density during annealing. Based on these results, we propose the mechanism of this stress behavior with quantitative analysis. Then the experiments to reduce these stresses were performed by control of oxygen gas flow rate. The addition of the excess oxygen suppressed the grain growth, leading to reduction of tensile stress effectively.

TF-TuP10 Phase Changes of Chromium Nitride Films Annealed in Vacuum, ***H.-Y. Chen***, *F.-H. Lu*, National Chung Hsing University, Taiwan

CrN films were deposited onto (100) Si substrates by a cathodic arc plasma deposition technique. The films were encapsulated in vacuum (~10^{-4} torr) and then annealed over the temperature range of 500°C to 1200°C for 2 hr. X-ray diffraction results showed that Cr_2N phase appeared over the whole temperature range. The relative integrated intensity of Cr_2N phase increased rapidly with temperature. Additional $CrSi_2$ phase was formed above 900°C, which was resulted from the reaction between CrN films and Si substrates. The formation energy of $CrSi_2$ was also discussed. The formation of Cr_2N phase above 900°C would be enhanced by the formation of $CrSi_2$. The CrN films were detached from Si substrates at relatively high temperature, which might be mainly due to the thermal stress stemmed from a large thermal mismatch between Si (α=$2.5x10^{-6}$ K^{-1}) and $CrSi_2$ (α=$9.0x10^{-6}$ K^{-1}).

TF-TuP11 Effect of Graphite Content on Carbon Nitride Films Prepared by Hot Carbon Filament CVD, *S. Aizawa, M. Aono, N. Kitazawa,* ***Y. Watanabe***, National Defense Academy, Japan, *O. Shimizu, Y. Suda*, Mitsubishi Pencil Co. Ltd., Japan

Carbon nitride (CNx) films were prepared on silicon single crystal substrates by hot filament chemical vapor deposition (HFCVD). Several kinds of carbon coils with different graphite contents, up to 90 %, were applied for the filament. The carbon coil was heated at about 2073 K in a nitrogen atmosphere of 100 Pa. The effects of the graphite content on the surface morphology and the nitrogen content in the CNx films were studied by using atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS). Contamination free CNx films were prepared successfully and the nitrogen content in the films is evaluated from the photoelectron peaks of carbon and nitrogen and the sensitivity factor of the XPS. AFM observations reveal that the surface roughness of the CNx films increases with the graphite content. It is found from the XPS analysis that the nitrogen content does not depend strongly on the graphite content. SEM observations of the carbon filament after deposition show that morphologies of the filament surface have changed with the graphite content. This suggests that emitting behavior of carbon clusters varies in accordance with the graphite content.

TF-TuP13 Influence of Nitrogen Concentration on Conductivity of N-doped a-SiC:H Films Deposited by PE CVD, ***J. Huran***, Slovak Academy of Sciences Bratislava, Slovakia, *I. Hotovy, J. Liday*, Slovak University of Technology Bratislava, Slovakia

The application of SiC in semiconductor device technology requires controlled and selective doping. Standard technologies for silicon device production, such as ion implantation at room temperature and the subsequent thermal annealing of radiation damage at moderate temperatures cannot be adopted because the radiation damage in SiC is extremely stable. Very high temperatures are necessary for its annealing and to activate dopants. One way to overcome this problem is to perform high current pulse electron or ion beam irradiation instead of high temperature annealing. Nitrogen-doped amorphous SiC films were grown by a PE CVD technique. Samples with different amounts of N were achieved by a small addition of ammonia into the gas mixture of silane and methane, which were directly introduced into the reaction chamber. The actual amount of nitrogen in the SiC films was determined by AES. The hydrogen concentration was determined by an elastic recoil detection method. For irradiation experiments we used electron beams with a kinetic energy 200 keV, a pulse duration of 300 ns, and a beam current of 150 A/cm^2. For the electrical characterization of the SiC films vertical diode structures were formed on the prepared SiC/Si samples. A quantitative analysis of the AES spectra was used to determine the concentration of carbon, silicon and nitrogen. It was found that with increased nitrogen doping and following activation of

dopants the resistivity of the amorphous SiC films was substantially reduced.

TF-TuP14 Nitride -based Tipless Cold Cathodes for Microdevice Applications, ***N. Badi***, *K. He, N. Medelci, A. Bensaoula*, University of Houston

This paper reports on the electron field emission from sulfur doped boron nitride thin films deposited on Si, TiN/Si, and hydrogen plasma roughened silicon (Si: H_2) substrates by a filamentless End Hall ion source -assisted physical vapor deposition technique. Patterned S-BN/TiN/Si and TiN/SiO_2/S-BN/TiN/Si arrays were also fabricated by using a combination of selective wet etching and photo-assisted reactive ion etching (PA-RIE) processes. The TiN interfacial layer and the substrate morphology influence considerably the emission properties of sulfur-BN layers. Preliminary results show an enhancement in emitted current density and a reduction in threshold voltage. To investigate the effects of heat treatment and pressure on field emission, in-situ thermal annealing up to 250 °C was carried in vacuum and in a controlled air ambient. The I-V characteristics of our samples did not significantly change in a pressure range from 8 x 10^{-8} to 3 x 10^{-5} Torr. Temporal stability measurements at different pressures show only a small current density fluctuation. These results are encouraging as far as device operation in harsh environments.

TF-TuP15 Electrical and Optical Properties of a-C:H:Si Films Deposited by r.f. Plasma Chemical Vapor Deposition, ***I.J. Kim***, *Y.T. Kim, W.S. Choi, D.H. Yoon, B. Hong*, Sungkyunkwan University, Korea

Research in recent years has been made to study the incorporation of silicon atoms into hydrogenated amorphous carbon(a-C:H:Si) films with interesting results. Films with very low friction coefficients, improved adhesion and increased sp^3 character have been reported. However, an investigation of the electrical and optical properties of silicon incorporated hydrogenated amorphous carbon(a-C:H:Si) films is still lacking. In this study, we present the results obtained for electrical and optical properties of silicon incorporated hydrogenated amorphous carbon(a-C:H:Si) films deposited on Si(100) wafers and corning 7059 glass from radio-frequency glow discharge of mixtures of methane and silane gas. The flow rates of CH_4 and H_2 were fixed at 10 Sccm and 90 Sccm, respectively, and the SiH_4 flow rate was varied from 0 to 2.0 Sccm. We have used Raman spectrophotometer, ultra violet-visible(UV-VIS) spectrometer and Fourier transform IR(FT-IR) for determining optical properties and current-voltage(I-V) measurement for electrical proprties.

TF-TuP16 Pulsed Laser Deposited Zn_2GeO_4: Mn Thin Films for Field Emission Displays, ***L.C. Williams***, *D.P. Norton, P.H. Holloway*, University of Florida

Field emission displays (FEDs) are among several technologies competing to become the principal device in the flat panel display market. Thus, the development of low voltage phosphors are critical. Thin film phosphors offer the following advantages over powder phosphors: better mechanical integrity, more efficient use of material, and better heat sinking. Thin film Zn_2GeO_4: Mn has been pulsed laser deposited in this study and its cathodoluminescent properties were characterized. The Zn_2GeO_4: Mn thin films were deposited onto MgO, yttria stabilized zirconia (YSZ), and Si substrates. In addition, the deposition temperature was varied from 600 to 750 °C. The best cathodoluminescent brightness was observed from YSZ substrates. A green cathodoluminescent emission peak at 540 nm was observed for depositions at temperatures ≥ 650 °C. At a deposition temperature of 600 °C, a red shifted emission peak was observed at 650 nm. Observation of the red shifted peak correlated with the lack of crystallinity in the films deposited at 600 °C. The shift in emission will be discussed in view of reports that the emission from Mn is sensitive to the symmetry (octahedral versus tetrahedral) in a host lattice.

TF-TuP17 Study of GaPN Epilayers Grown by Molecular Beam Epitaxy, ***M.A. Santana-Aranda***, CINVESTAV-IPN, Mexico, *C. Mejía-García*, IPN, Mexico, *M. Meléndez-Lira*, CINVESTAV-IPN, Mexico, *G. Contreras-Puente*, IPN, Mexico, *M. López-López*, CINVESTAV-IPN, Mexico, *K. Momose, A. Utsumi, H. Yonezu, Y. Furukawa*, Toyohashi University of Technology, Japan

III-V-Nitrogen compounds open the possibility of monolithic integration on III-V based light emitting devices and Si based microelectronics. Small amounts of nitrogen in the GaPN alloy increase the light emitting efficiency of GaP. While, according to Vegard's rule, lattice matching of GaPN to Si is accomplished with around 2.1% nitrogen. In this work, we present the characterization of GaPN layers with up to 2.41% nitrogen content grown on GaP substrates by molecular beam epitaxy. Photoluminescence, contact-less electro-reflectance and Raman scattering measurements are performed in order to characterize the quality of the layers, and compared to results obtained with high-resolution x-ray diffraction, atomic force microscopy and transmission electron microscopy. The photoluminescence spectra are red shifted with increase of nitrogen content. The behavior of the energy band gap determined with the electro-reflectance measurements is compared to previously published calculations and experimental determinations. GaP-like LO mode, as observed by Raman scattering, is shifted toward lower frequencies because of two contributions; alloying and strain. Furthermore, high-resolution x-ray diffraction reveals that GaPN layers are partially relaxed, which is supported by transmission electron microscopy and atomic force microscopy. Transmission electron microscopy shows dislocations and micro-cracks for the samples with higher nitrogen content. Atomic force micrograph of the sample with 2.41% of Nitrogen show the presence of some grooves parallel to the direction, that are related to the process of strain relaxation.

TF-TuP18 Ultraviolet Emitting SrS:Te Thin Films, *P.D. Rack*, University of Tennessee, ***J.M. Fitz-Gerald***, University of Virginia

The development of semiconductor based ultraviolet (UV) light sources is of critical importance for miniaturized ultraviolet light sources which have application in biological agent detection, non-line-of-sight covert communications, water purification, equipment/personnel decontamination, and white light generation. To this end, a significant amount of research is currently being performed to extend the III-V nitride blue lasers and light emitting diodes into the ultraviolet region. In this paper we will discuss the ultraviolet emission of pulsed laser evaporated thin film SrS:Te. SrS has an indirect bandgap of ~ 4.32 eV and when doped tellurium ultraviolet emission occurs from bound excitons. Un-doped SrS thin film properties (crystallinity and composition) as a function of the growth conditions will be presented and the effect that the tellurium concentration has on the ultraviolet emission will be discussed. The nature of the bound excitons will be discussed along and thermal quenching data will be presented.

TF-TuP19 Growth and Characterization of Single Crystal Multi Layer Nano Structures for Fast Ion Conduction, *S. Azad, S. Thevuthasan, V. Shutthanandan, C.M. Wang, D.E. McCready, J.W. Stevenson, S. Baskaran,* ***C.H.F. Peden***, Pacific Northwest National Laboratory

Recently, considerable interest has been shown in the growth and characterization of nanoscale materials since they often have very different properties from the bulk material. It has been demonstrated that restructuring simple ionic crystals at the nano scale can alter the electrical properties of ion conducting materials. Such materials have potential applications in solid electrolyte-based devices such as high-temperature batteries and fuel cells.[1] Recently, we successfully grew epitaxial single-crystal multi layer thin films of pure and mixed ceria and zirconia on single-crystal yittria-stabilized zirconia (YSZ) substrates at the Molecular Beam Epitaxy facility of the Environmental Molecular Sciences Laboratory (EMSL). The films, with different thickness, were grown at various substrate temperatures in order to investigate the role of substrate temperature and film thickness on ionic conductivity. The interface between pure and mixed ceria films and YSZ substrates showed misfit dislocations, and the defect density at the interface affected the ionic conduction. These films were characterized using in-situ reflection high-energy electron diffraction (RHEED), ex-situ x-ray diffraction (XRD), high-resolution transmission electron microscopy (HRTEM) and Rutherford backscattering spectrometry (RBS) along with ion channeling. These results will be discussed along with the ionic conductivity measurements from these films and substrates.

Work supported by the U.S. Department of Energy, Offices of Basic Energy Sciences and Biological and Environmental Research.

[1] N. Sata, K. Eberman, K. Eberl and J. Maier, Nature 408 (2000) 946.

TF-TuP20 Molecular Beam Deposition of Yttrium Oxide as a Host Material of Er Doping for an Optoelectronic Amplifier Application, *B. Cho,* ***T. Van***, *J.P. Chang*, University of California, Los Angeles

Erbium has been extensively used as a doping material for silicon-based optoelectronic amplifiers due to the 1.54 μm light emission from its trivalent ion, which is one of the standard wavelengths in optic communication. We deposited yttrium oxide as a host material for erbium doping using molecular beams from metal-organic precursor with bera diketonate structures, $Y(TMHD)_3$ [TMHD; tris (2,2,6,6-tetramethyl-3,5-heptanedionato)] as well as H, N, and O atom beams and Ar^+ ion beam. We chose Y_2O_3 as a waveguide core material because it has higher Er solubility and refractive index than silicon or silica, enabling higher signal gain on smaller dimension devices. However, the Er dopants should be evenly distributed to reduce the cooperative upconversion effects leading to the decrease in quantum yield. We could achieve high quality epitaxial films at lower temperatures than required in prevailing sputtering or ion implantation methods by controlling the beam fluxes and energies. During the deposition we monitored the in-situ deposition/etching rates using a quartz crystal microbalance. This low temperature process could reduce the

Er diffusion, segreagation, and precipitation resulting in deleterious effects on Er luminescence. Optically-active Er complexes can be easily incorporated into the growing Y_2O_3 film without causing defects in the host material since the coordinations are preserved in the precursor molecules as well as Er-O has a lattice constant very similar to Y_2O_3 film. We investigated the effects of substrate and doser temperatures, fluxes and energies of the beams on the dopant concentration, its spatial distribution, and the film structure and composition. To this end, we characterized the deposited samples using SIMS, LEED, XRD, and XPS.

TF-TuP21 Infrared Emission from Electroluminescent Thin Film ZnS Doped with Rare Earth Fluorides, ***W. Glass***, *A.S. Kale, M. Davidson, P.H. Holloway,* University of Florida

Alternating current thin film electroluminescent devices (ACTFELDs) are well-known thin film structures used for flat panel displays. A well-known phosphor for such displays is ZnS doped with either transition or rare earth elements. The infrared emission from these types of materials is often overlooked except in the case of ZnS:ErF_3, which has been of interest for fiber optic communications. The infrared intensity of these phosphors is dependent on the environment of the luminescent centers and can be improved by modification of deposition and processing. In this study, rare earth fluoride doped ZnS films were deposited by RF planar magnetron sputter deposition. Deposition temperature was varied to determine temperature effects on brightness and crystallinity. In addition, the rare earth concentration was changed from a maximum of 1.6 mol% to zero by simultaneously sputtering an undoped ZnS target. Similarly, films containing two rare earths have been produced by simultaneously sputtering two rare earth containing targets. These films were used to determine the effects of concentration and energy transfer between rare earth dopants. The devices were then excited by electroluminescence to determine the optimal conditions for infrared emission. Finally, emission from materials with similar and dissimilar luminescent decay paths will be discussed.

TF-TuP22 Solutions for the Deposition of Complex Optical Filters with Dual Ion Beam Sputtering, ***R. Blacker***, *D. Deakins, A. Dummer, J. George,* Veeco Instruments Inc., *Y. Godwal,* Colorado State University, *I. Kameyama, S.M. Lee, N. Van Lieu,* Veeco Instruments Inc., *C.S. Menoni,* Colorado State University, *D. Siegfried,* Veeco Instruments Inc., *G. Vaschenko,* Colorado State University, *C. Montcalm,* Veeco Instruments Inc.

Demand for complex optical filters with increasingly tighter tolerance specifications is expanding. The need for more complex strategies to meet filter performances is also becoming increasingly apparent. The requirements for ultra low loss filters, low reflectivity filters (<-40 dB), highly specified broadband filters (gain flattening, beam splitter) and tight narrow band filters (50 GHz and 25 GHz dense wavelength division multiplex) are becoming more stringent, hence the need for ever more complex strategies to meet these demands.This paper presents examples of such complex filters in the context of their usage and required specifications, illustrating the degree of accuracy required during deposition to allow such filters to be realized. We present techniques using ion beam deposition that allows the layer thickness accuracies to be increased over currently obtainable levels. Optical monitoring strategies, substrate temperature control, robust filter design and ion source improvements are illustrated as specific examples. The suitability of current technology for anticipated future needs is explored, and areas of potential improvement are identified.

TF-TuP23 Study of the Oxidation Rates of Vanadium and Scandium, ***N.D. Webb***, *G.A. Acosta, D.D. Allred,* Brigham Young University

A study of the oxidation rates of thin films of vanadium and scandium was performed using an ellipsometer operating between 800 and 200 nm. Thin films of vanadium and scandium (between 40 and 150 A) were deposited on silicon substrates using a DC magnetron sputter system in a vacuum chamber. The samples were annealed at several temperatures between 90 to 200 C, with ellipsometric measurements taken periodically during the annealing process. This data was analyzed to determine the oxidation rates as a function of temperature and time, the activation energy of the oxides, and the swell factors. The oxidation states of the oxide films were determined using x-ray photoelectron spectroscopy. From our earlier work we found published, bulk constants were not appropriate for use with films this thin. We experimentally determined thin film, sputtered vanadium and scandium constants, as well as those for the subsequent oxides, in the visible and extreme ultraviolet (EUV). This work is part of a larger project; we are designing a vanadium and scandium multilayer mirror that will exhibit high reflectivity in the EUV.

TF-TuP24 The Distribution of Ge during Oxidation of epi-$Si_{1-X}Ge_X$, ***B.G. Min***, *S.-K. Kang, Y.H. Hong, D.-H. Ko,* Yonsei University, Korea

Silicon Germanium alloys have been received considerable attention in recent years for their potential application in advanced electronic and optoelectronic devices. The oxidation behavior of this material continues to be a troublesome issue that impedes its timely development. The distribution of Ge and the oxidation mechanism of epi-$Si_{1-X}Ge_X$ have been investigated. The epi-$Si_{1-X}Ge_X$ was deposited by UHV-CVD at 650$_o$C. The atomic fraction of Ge were 0%, 15% and 30%. The thickness of epi-$Si_{1-X}Ge_X$ layer is 30nm. Oxidations were performed at 800, 850, 900°C under 1atm of dry and wet O_2 for various time. Oxidation rates were compared with various Ge contents from 0% to 30%. The formed oxide was pure SiO_2 and Ge atoms piled up at the SiO_2/ $Si_{1-X}Ge_X$ interface. Contents and regions of Ge-rich layer were varied with the Ge contents and oxidation rates. It was due to different diffusion mechanism of Si source in the epi-$Si_{1-X}Ge_X$ with that in pure Si substrates during oxidation. By AES and HRTEM analyses, we observed the contents of Ge and the width of Ge-rich layer. In addition, we will discuss the electrical properties of MOS capacitor with Pt gate electrode.

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