Tuesday Afternoon Poster Sessions

Applied Surface Science

Room: 4C - Session AS-TuP

Aspects of Applied Surface Science Poster Session

AS-TuP1 Exploring the Complementary Nature of ToF-SIMS and ESCA Depth Profiling, ***K.G. Lloyd***, *L. Zhang, J.R. Marsh, M.A. Plummer*, The DuPont Company

Depth profiling -- the removal of material with nanometer depth resolution while analyzing with surface-specific techniques that probe only the newly-revealed surfaces – is an important characterization component of the electronics industry. Secondary Ion Mass Spectrometry (SIMS) and X-ray Photoelectron Spectroscopy (XPS, a.k.a. ESCA) depth profiling are currently offered by the DuPont CCAS (Corporate Center for Analytical Sciences) organization and DuPont Analytical Solutions. Characteristics of the technique and the sample to be studied often determine which technique is more appropriate. These include detection limits, lateral resolution, thickness regime, and the type of chemical information required (elemental vs. functional group/oxidation vs. molecularly-specific). More recently, SIMS depth profiling with a Time-of-Flight (ToF) analyzer offers high mass resolution, spatially-resolved chemical information, and the collection of the entire mass spectrum at each depth interval. In addition, the combination of ToF-SIMS depth profiling and chemometric/multivariate methods of data analysis allows better definition and characterization of interfacial regions between layers, as well as buried defects. This has called for a reassessment of how and when the two depth-profiling techniques (ESCA and ToF-SIMS) can provide complementary information. Topics including oxidation state, organic information, and influence of different sputter sources will be discussed with examples.

AS-TuP2 Ultra-thin Titanium Films as Deuterium Storage Material; Thermal Desorption Kinetics Studies Combined with Microstructure Analysis, ***E.G. Keim***, University of Twente. MESA+ Institute, The Netherlands, *W. Lisowski*, Polish Academy of Sciences, Poland, *M.A. Smithers*, University of Twente, MESA+ Institute, The Netherlands, *Z. Kaszkur*, Polish Academy of Sciences, Poland

Thin titanium films can be applied as hydrogen storage material due to titanium hydride (deuteride) formation. However, the morphology of the Ti films, which depends strongly on the Ti film thickness, affects both the deuterium sorption and titanium deuteride decomposition properties.[1] Here we present the results of TDMS, XRD, SEM and TEM, showing adsorption-desorption properties of ultra-thin Ti films as well as surface and bulk film morphology changes due to titanium deuteride (TiDy) formation. Ti films, 10-20 nm thick, were prepared in a UHV glass system[2] at 300 K. Both volumetrically controlled deuterium adsorption and TDMS[3] monitored deuterium evolution was carried out in situ, all other analyses ex situ. It was found that ultra-thin Ti films of fine grained bulk morphology (average grain size about 10 nm) form a TiDy phase with low deuterium content ($y \leq 1.2$) after deuterium treatment at 1 Pa pressure. SEM and TEM/XRD analyses reveal a very fine grained (smaller than 8 nm) surface and bulk film morphology. TDMS heating induced decomposition of ultra-thin TiDy films proceeds at low temperature (maximum peak temperature T_m about 500 K) and its kinetics is dominated by a low energy desorption ($E_D = 0.61$ eV) of deuterium from surface and subsurface areas of the Ti film.

[1] W. Lisowski, E.G. Keim, Z. Kaszkur, M.A. Smithers, Langmuir, 2007, submitted.

[2] W. Lisowski, Vacuum, 54, 13 (1999).

[3] W. Lisowski, E.G. Keim and M.A. Smithers, J. Vac. Sci. Technol. A21, 545 (2003).

AS-TuP3 Scanning Auger Microanalysis of M316LN Alloy Used as a Superconducting Magnet Conduit Material, *H.M. Meyer III, R.M. Trejo*, Oak Ridge National Laboratory, ***S.T. Downey II***, *P.N. Kalu, K. Han*, FAMU-FSU College of Engineering

This poster presents the characterization of chemically modified 316LN used as a conduit alloy in Superconducting Outsert of the 45T Hybrid Magnet System housed at the NHMFL. The conduit material acts as a protective jacket and carrier of the Nb_3Sn superconductors formed within the magnet coil. This alloy was developed to withstand the deteriorative effects of the Nb_3Sn reaction heat treatment while maintaining high strength, toughness and ductility at liquid helium temperatures. This heat treatment, necessary for forming the Nb_3Sn superconductors within the magnet coil, is known to cause sensitization in most unmodified austenitic steel grades. Sensitization is the formation of brittle, chromium rich phases which degrade the mechanical behavior of this structural material. Cryogenic mechanical testing of M316LN upon exposure to the high temperature, long duration heat treatment (700C for 100 hours) was used to validate its current use. Mechanical tests show a significant loss in fracture toughness (~45%), although little microstructural characterization has been performed to support these findings. This poster describes our effort to provide microstructural and chemical characterization of the M316LN alloy exposed to the prescribed environments. In particular, we present scanning Auger microanalysis of the changes in chemical composition at the grain boundaries of M316LN caused by the heat treatment and resultant precipitate formation. Correlation of the Auger results with nanohardness tests at the grain boundaries will be presented. Research sponsored in part by the NSF through the Partnership for Research and Education in Materials Science under Grant No. DMR-0351770 and in part by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of FreedomCAR and Vehicle Technologies, as part of the High Temperature Materials Laboratory User Program, Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract number DE-AC05-00OR22725.

AS-TuP4 Chemical Reaction of Alkali Metal with 1,3-butadiene on Si(100)2x1 Surface, ***H.Y. Park***, Korea Research Institute of Chemical Technology, *S.H. Kim, J.R. Ahn*, Sungkyunkwan University, Korea, *K.-S. An*, Korea Research Institute of Chemical Technology

The chemical adsorption of Na with 1,3-butadiene (BD)overlayer on Si(100)2x1 surface have been studied using X-ray photoelectron spectroscopy and synchrotron radiation photoemission spectroscopy in order to investigate the possibility of organic molecule-metal multilayered structure on semiconductor surface using unsaturated functional group of molecule on the top layer. As well known, the ethylene-like overlayer was induced by BD adsorption on Si(100)2x1 surface with [4+2] cycloaddition reaction (Diels-Alder reaction) at RT without breaking Si dimer. At low coverage of Na adsorption on the BD overlayer, large binding energy shift of C 1s core level spectrum was induced, which may be explained by Fermi level shift due to charge transfer from adsorbed Na to anti-π bonding state of C=C. Interestingly, the BD overlayer induces metallic Na layer beyond the RT saturation at higher coverage although Na adsorption on clean Si(100)2x1 surface has a saturation coverage (1 monolayer by double layer model) at RT. In this study, from work function changes, core level shifts, and valence band spectra, the chemical reaction of Na with ethylene-like BD overlayer on Si(100)2x1 surface are discussed.

AS-TuP5 Coding and Functionalization of Nanoparticles for Forming Photonic Bandgap Structures, *Y.-T. Kao, H.-T. Su*, ***C.-C. Chang***, National Taiwan University

Developing chemical strategies for synthesizing and characterizing functionalized nanoparticles and microspheres on which atomic aggregates of unique properties are coded for forming a lattice of repeating patterns as the photonic crystal are of great challenge for elevating photonic crystal research towards practical photonic device fabrication. When used in the photonic circuitry system, the crystal containing property-enhancing, functionalized microspheres must possess, among others, high degrees of optical clarity. This mandates high quality dispersions of the functionalized nanomaterials within the host matrix. Nanoparticles and microspheres of different chemical compositions and refractive indexes have been synthesized using a variety of chemical synthetic approaches. They were then coated with metal nanoparticles or functionalized with inorganic linkers, which were well dispersed on the surface of unit spheres. Photonic crystals were produced by self-assembly of these unit spheres through gravity or pressure. A variety of analytical methods were employed to reveal the chemical process involved in the synthesis, coding and functionalization of the unit spheres. Selective binding of species with unique functions to the surface of the unit materials was achieved by pretreating the materials surface, designing precursor molecules, and controlling the reactions involved in coding and functionalization. The bonding, reaction chemistry as well as the chemical identification of the species that were coded on the model unit materials surface will be discussed.

AS-TuP6 Addition of Surface-Modified Silsesquioxane Nanofillers for Thermal Stabilization of Polymer Thin Films, ***N. Hosaka***, *K. Miyamoto, H. Otsuka*, Kyushu University, Japan, *N. Yamada, N. Torikai*, KENS, Japan, *A. Takahara*, Kyushu University, Japan

Polymer thin films have numerous technological applications which require the homogeneous film. However, producing stable films is problematic since the polymer thin films tend to dewet from the substrates. Various approaches have been adopted to stabilize these films against dewetting, and recently, much interest has focused on the use of additives to improve the thin film stability. In this paper, polyhedral oligomeric silsesquioxanes

(POSS) were used as a nanofiller. POSS have gained considerable attention due to their organic-inorganic hybrid structure which consists of a silica cage with organic groups. The salient feature of this nanosized material is the ability to functionalize the silicon corners with a variety of organic substituents. Our previous study showed that the blending of cyclopenty substituted-POSS (CpPOSS) with the polystyrene (PS) thin films led to an inhibition of dewetting in the films.[1] Structural analyses of the films revealed that CpPOSS segregated to the film surface and film-substrate interface, and the inhibition of dewetting can be attributed to the segregation of CpPOSS, accompanying modification of the energetics and morphologies of the interfaces. However, the film with CpPOSS had a problem that its surface was roughened by the aggregation of CpPOSS. Present work is focused on the surface modification of POSS with several organic groups and PS chains to improve the dispersibility of POSS in PS films. Furthermore, the dispersion state of the surface-modified POSS in the film, especially at the surface and interface of the films, was investigated, and the relationship between dewetting inhibition and structure of the film was discussed. The dispersibility of POSS in PS films depended on the surface composition, and POSS with PS chains dispersed well in the films and also stabilized the film against dewetting.[2] Smooth surface morphology of the PS film with POSS modified by PS chains was observed by atomic force microscopy. Neutron reflectivity measurements revealed that the POSS still had the tendency to segregate to the film surface and interface even after the introduction of a PS chain on its surface, and this structure seems to be preferable for the inhibition of dewetting of the films.

[1] N. Hosaka, N. Torikai, H. Otsuka, A. Takahara, Langmuir, 23, 902-907 (2007).

[2] K. Miyamoto, N. Hosaka, H. Otsuka, A. Takahara, Chem. Lett., 35, 1098-1099 (2006).

AS-TuP7 2 Dimensional Map of Field Emission Properties of CNT Emitters Fabricated by a Screen Printing Process

***W.H. Han**, T.Y. Park, C.J. Kang, Y.S. Kim, J.W. Kim, Y.J. Choi*, Myongji University, Korea

The spatial uniformity and durability of field emission is one of the main issues in the carbon nanotube (CNT) field emission devices fabricated by a screen printing process. In this paper, we propose novel method to visualize field emission sites of CNT films two-dimensionally by adopting scanning probe microscopy technique and verify the conditions where the field emission of CNT emitters is spatially uniform and durable. While the anode probe with a small tip diameter of <100nm was scanned over CNT emitter surface whose dimension is 200um*200um, the field emission current was recorded through Keithley 6517A, converted into 256 grayscale level and displayed on monitor through LabView program. The anode probe was made by electro-chemically etching tungsten wire and the CNT emitter sample was fabricated by screen printing multiwall CNT whose diameter is 4-6nm and length is 1-2um on the indium-tin-oxide (ITO) glass. During scanning, the gap between W anode and ITO glass surface was maintained to be few tens of um. For the large scale imaging, we used the inertial nano positioner whose model number is ANPxyz100 made by Attocube Systems as a long range scanner. With this system, we could not only measure the emission turn-on field at fixed locations but also obtain the electron emission current map over large surface areas under constant anode voltage. We will discuss the relation between the local geometry and field emission properties of CNT emitter, and the fabrication condition of CNT emitters where the field emission is uniform and stable.

AS-TuP8 Characterization of Vertical Arrays of ZnO Nanorod by AFM

***Y. Hou**, A. Andreev, C. Teichert,* University of Leoben, Austria, *G. Brauer,* Forschungszentrum Dresden-Rossendorf, Germany, *A. Djurisic*, University of Hong Kong, P.R. China

Solar cells made from an array of high-quality vertical ZnO nanorods filled with a light-absorbing, hole conducting polymer are promising devices for efficient low-cost solar energy conversion.[1] However, achieving full control over the growth of such nanostructures leading to proper dimensional confinement (like nanorod diameter, length, density and orientation) is still a challenging task. On the other hand, Atomic Force Microscopy (AFM) is well known as a valuable tool for nanometer scale characterization of different types of nanostructures.[2] The capabilities of AFM technique are demonstrated for the characterization of vertical arrays of various ZnO nanorods.[3] In detail, the topography of the ZnO nanorods grown on Si and ITO substrates was examined. It was found that tapping mode AFM is an appropriate tool to reveal the morphological features of vertical ZnO nanorods on the nanoscale, i.e. 3D rod shape, lateral size, average height and rod height uniformity. The results are compared with those obtained by Scanning Electron Microscopy. Moreover, by cross-sectional AFM measurements it was also established that intermediate facets appear between the top (0001) and side facets. Further, polymer coated ZnO nanorods have been investigated by AFM.

[1] E. Greene, et al., Nano Lett. 5 (2005) 1231-1236.

[2] C. Teichert, Phys. Rep. 365 (2002) 335-432.

[3] G. Brauer, W. Anwand, D. Grambole, W. Skorupa, Y. Hou, A. Andreev, C. Teichert, K. H. Tam, A.B. Djurišic, Nanotechnology 18 (2007) 195301-1-8.

AS-TuP9 Characterization of Ceramic Materials using Electron, Ion, X-ray, and Optical Techniques

***B.W. Schmidt**, B.R. Rogers, J.M. Burst, R.D. Geil, M.R. George, N.D. Vora*, Vanderbilt University

Ceramic materials are widely used because of their hardness, thermal stability, and electrical properties. However, these characteristics also present issues when it comes to processing. Powder pressing is commonly used, but due to the variability in powder sizes and structures, reproducibility is difficult. Therefore, fundamental understanding of interfaces and surfaces is critical to modeling efforts. Our group uses thin film experiments to gain insight into basic mechanisms, which can then be applied to more complicated systems. We are focusing on aluminum and hafnium-based materials. Al$_2$O$_3$ is used extensively today because of its low cost and excellent protective properties. Chemical vapor deposition of Al$_2$O$_3$ typically includes trimethylaluminum (TMA), a dangerous pyrophoric compound. Dimethylaluminum isopropoxide (DMAI) is an alternative precursor that displays the same high vapor pressure that makes TMA desirable, but also shows stability as a liquid in ambient conditions. Hafnium oxide materials have received recent emphasis as high-κ replacements of silicon dioxide in CMOS devices. In addition, the borides and carbides of hafnium also can be used in high temperature applications such as hypersonic flight and atmospheric re-entry. In this work, we provide examples of how Auger electron spectroscopy, Rutherford backscattering spectrometry, time-of-flight medium energy backscattering spectrometry, X-ray photoelectron spectroscopy, and spectroscopic ellipsometry have been used to characterize these ceramics.

AS-TuP10 Room Temperature Nanoimprinting of Crystalline Poly(fluoroalkyl acrylate) Thin Films

***K. Honda**,* Kyushu University, Japan, *M. Morita,* Daikin Industries, Japan, *A. Takahara*, Kyushu University, Japan

Various studies have been done on the nanofabrication of polymeric materials. However, most of the studies utilize conventional polymers and little attempt has been done for the design of polymeric materials for nanofabrication. In this study, room temperature nanoimprinting of polymer thin films will be presented. Nanoimprinting technology using compression molding of thermoplastic polymers is a low cost mass manufacturing technology and has been around for several decades.[1] The polymer used for nanoimprint experiment is Poly(2-(perfluoroocthyl ethyl) acrylate) with long fluoroalkyl group (PFA-C$_8$). In previous report, the authors studied wetting properties and surface molecular aggregation of PFA-C$_8$ thin films and clarified that PFA-C$_8$ showed the high water repellency because of crystaliization of long fluoroalkyl group.[2,3] PFA-C$_8$ was spin-coated on the Si-wafer. The film thickness was estimated as approximately 500 nm by atomic force microscopy (AFM). The mold patterned with lines (L/S of 500 nm) was imprinted onto a spin-coated PFA-C$_8$ thin film under various imprinting conditions and nanoimprinting characteristics of PFA-C$_8$ was investigated on the basis of scanning elerctron microscopy (SEM), AFM and contact angle measurement. The line patterns were observed on PFA-C$_8$ film surface by AFM and SEM. In addition, PFA-C$_8$ film was sucessfully nanoimprinted at room temperature because of the weak interaction among rigid fluoroalkyl groups in crysatallite. The nano-textured PFA-C$_8$ exhibited super hydrophobicity as well as high oleophobicity. Also, line imprinted surface showed anisotropic wetting behavior. The super hydrophobicity was explained by the notion of heterogeneous wetting proposed by Cassie. In this case, the space between the solid surface and probe liquid was occupied by air and consequently the contact angle was increased.

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[3] K. Honda et al., Trans. Matter. Res. Soc. Jpn., 32, 239 (2006).

AS-TuP11 Short and Long-term Sputter Rate Constancy Measurements

***A.S. Lea**, M.H. Engelhard, D.R. Baer, P. Nachimuthu*, Pacific Northwest National Laboratory

The use of ion sputtering to obtain relative and absolute depth information about surface layers and films is a common application of Auger and photoelectron spectroscopy. Accurate information about sputter rates for different materials and reproducible information for similar systems requires that the conditions of operation of an ion gun be fairly well characterized and the parameters needed to obtain reproducible sputter conditions be understood. Unfortunately, most of us do not have a good sense of how stable and reproducible our actual sputter rates are. We have undertaken a study to determine the constancy of sputtering over short and long periods of times as these determine how long of a warm-up time is necessary prior to conducting sputter rate profiles, how much variability occurs during the course of an experiment, and how often one must perform sputter rate calibrations. We have three surface analysis systems, either manually or digitally controlled, in which we are conducting these constancy measurements. We have found that for one digitally controlled system, sputter rate are fairly constant over a period of a year. In the short term, sputter rates are constant following a short warm-up time. For a manually controlled system, the sputter rate is constant over a period of days provided the settings do not change over that period of time. Determination of the long-term variability of a manually controlled system for argon ion sputtering at fixed energies is part of an on-going effort. These sputter rate constancy measurements are being conducted in a Phi Quantum 2000 XPS system, a Phi 680 Auger Nanoprobe system, and a Kratos Axis 165 multitechnique system. We will provide comparisons of sputter rate constancy for these systems over the short and long-term.

AS-TuP12 Interaction of Cobalt with Weathered Steel Surfaces Studied by XPS, ***D.L. Blanchard Jr.***, *I.E. Burgeson, G.J. Lumetta, J.R. DesChane,* Pacific Northwest National Laboratory, *G.W. Wagner*, Edgewood Chemical Biological Center

Researchers at the U.S. Army Edgewood Chemical Biological Center have developed and tested a solution for decontaminating surfaces from biological and chemical warfare agents: DECON GREEN^{TM}. Prior tests conducted at the Pacific Northwest National Laboratory (PNNL) to examine the efficacy for removal of radionuclides showed that the effectiveness of DECON GREEN^{TM} in removing Co from aged steel, though better than water, was considerably lower than that observed for other surfaces. Only about 50% of the Co could be removed from the steel surface using DECON GREEN^{TM}. In the current work, the mechanism of the Co adhesion to the steel was investigated using X-ray Photoelectron Spectroscopy (XPS). Cobalt(II) chloride ($CoCl_2$) aqueous solution was pipetted onto a weathered steel coupon and allowed to air-dry. The coupon was examined by XPS to determine the chemical state of the resulting cobalt deposit. An untreated, weathered steel coupon was examined as a control, and samples of cobalt metal foil and $CoCl_2$ powder were examined as reference compounds. The steel coupon treated with the $CoCl_2$ was rinsed with water after the initial XPS analysis, then re-examined to identify any changes in the cobalt chemical state. The coupon was then treated with DECON GREEN^{TM} and rinsed with water, and re-examined. The key observations are: 1) The cobalt on the weathered steel coupon was mainly metallic, based on the shape and position of the Co $2p_{3/2}$ XPS peak, indicating that cobalt(II) in the applied solution was reduced to metal at the surface. The appearance of shoulders on the high binding energy side of the main peak suggested the presence of a small amount of oxidized cobalt. The iron in the weathered steel coupon was somewhat oxidized before the cobalt deposition; the deposition further oxidized the iron. 2) Rinsing with water did not significantly change the shape of the Co $2p_{3/2}$ XPS peak; the shape and position still indicate mainly Co metal with some oxidized cobalt, probably a cobalt hydroxide or oxide. Rinsing oxidized all the iron metal at the surface, and greatly increased the fraction of oxygen on the surface. 3) Treating with DECON GREEN^{TM} increases the fraction of oxidized cobalt at the surface, but the majority is still metallic. The iron may undergo some additional oxidation. The DECON GREEN^{TM} treatment left carbon at the surface, probably from organic constituents.

AS-TuP13 Plasma Enhanced Chemical Vapor Deposition of Trimethylsilane on Ion Vapor and Physical Vapor Deposited Aluminum, ***P.R. Scott***, *D.M. Wieliczka*, University of Missouri - Kansas City

X-ray photoelectron spectra were obtained after each stage of a plasma deposition process with depth profiles to the aluminum layer. Spectra were obtained from Silicon wafers prior to processing; and after Argon ion plasma etching, vapor deposition of Aluminum, and DC plasma deposition of trimethylsilane. The samples were transferred under vacuum from the plasma chamber to a Kratos AXIS HS x-ray photoelectron spectrometer. Spectra were taken with magnesium K-alpha x-rays at a base pressure of 10^-9 Torr. Argon plasma etching removed carbon contamination, but left a residual oxide on the surface. Aluminum ion vapor deposition films were created at 100mTorr of Argon while physical vapor deposition films were created at a pressure of 10^-7 Torr. Results of a comparison between the ion vapor deposition and physical vapor deposition films will be presented. Various plasma deposition parameters were used to produce the trimethylsilane thin films.

AS-TuP14 Sputter Rate Determinations for Different Forms of ZnO, TiO2, and Al2O3, ***M.H. Engelhard***, *T.C. Droubay, L.V. Saraf, P. Nachimuthu, A.S. Lea,* Pacific Northwest National Laboratory, *W. Stickle,* Hewlett Packard, *C. Mathews, B. Lee, J. Kim, R.M. Wallace,* University of Texas at Dallas, *D.R. Baer*, Pacific Northwest National Laboratory

Oxide films play increasingly important roles in several modern technologies, including integrated circuits, fuel cells, and sensors. Important to the use of surface analysis techniques to characterize a variety of these materials systems is the knowledge of the sputter rates for different oxides. Since research in our laboratories and for users of the US Department of Energy’s Environmental Molecular Sciences Laboratory (EMSL) user facility involves the use of oxide films and particles, we have been building an oxide sputter rate database by examining thin films grown by oxygen plasma-assisted molecular beam epitaxy (OPA-MBE). These studies demonstrate that we can usually obtain sputter rate reproducibility of better than 5% for similar oxide films grown by OPA-MBE. However, it is well known that there are many sputtering artifacts that can occur including those due to crystal orientation, structure, or the presence of impurities. In order to examine the general applicability of the information from the epitaxial film "standards" to other materials, we are measuring the sputter rates for oxide films for a different crystal structures and/or deposition techniques. Here, we report measurements of sputter rates for ZnO, TiO2 , and Al2O3 films prepared by pulsed laser deposition, chemical vapor deposition, or atomic layer deposition. We are currently examining the dependency of density as well as crystal structure on sputter rates. X-ray reflectivity (XRR) has been used to measure the thickness and density of these films and sputter rates are measured using a PHI Quantum 2000 Scanning ESCA Microprobe. The measured sputter rates are compared to rates for known thicknesses of SiO2/Si. Work at PNNL is supported by the Department of Energy and work at UT-Dallas is supported in part by the Semiconductor Research Corporation.

AS-TuP15 Ion Beam Tuning and Optimization of Nova Ion Gun in Kratos Axis Ultra DLD Spectrometer, ***H. Piao***, *J. Chera, V. Robinson*, General Electric Co.

The first part of this study focuses on the Nova ion gun beam tuning and the resulting XPS depth profiling measurements based on a standard SiO2/Si sample under different measuring conditions (ion beam energies from 0.5-4 keV). The quantitative evaluation of depth profiles in terms of sputter rate and depth resolution is discussed in more details. Changes of topography resulting from sputtering (roughness increases with sputtering time and depth) are also given a full attention. Then we report the advantages of the "float" mode with the production of relatively high current, low energy ion beams for enhanced depth resolution. Practical application of its depth profiling at interfaces is further elucidated by a typical example: SiOxNy(40nm)/SiOxCy(300nm)/SiOxNy(40nm) thin film. Finally, the improvement of the depth resolution by rotating the sample azimuthally is demonstrated.

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