Schedule	Paper Number	Title
Tue 12:40PM	EW-TuL-3	A New Cluster Ion Beam for Depth Profiling Challenging Organic Materials

John S. Hammond (Physical Electronics)

C_{60} and coronene cluster ion sources have been recently introduced for XPS and TOF-SIMS sputter depth profiling of many polymer materials. These sources have also been very successful for the removal of common organic contamination before XPS and TOF-SIMS surface analysis. This experience with C_{60} and coronene cluster ion sources has revealed several polymer systems for which these cluster sources can not produce “non-destructive” chemical depth profiling with XPS and TOF-SIMS. Typically these polymers are either cross-linked, highly susceptible to radiation induced cross-linking, or are polymerized with bonds that are not amenable to sputter depth profiling. A new gas cluster ion beam (GCIB) source that produces massive argon cluster ions will be shown to successfully produce XPS and TOF-SIMS depth profiles on challenging materials such as polyimide thin films. The GCIB source can also be used to remove ion beam and plasma induced damaged layers on polymer materials.

This new ion source will greatly expand the breadth of materials for which XPS can produce chemical state depth profiles on multi-layer thin films. In addition, the use of a dual beam depth profiling approach with GCIB and LMIG sources on TOF-SIMS instruments will expand the applications for 3D characterization of polymer and biomaterial samples. Examples will be presented demonstrating the benefits of the GCIB for both XPS and TOF-SIMS analyses.

Tue 4:20PM	AS-TuA-8	From Depth Profiling to FIB Sectioning for 3D TOF-SIMS Imaging of Organics

Gregory Fisher (Physical Electronics); Scott Bryan (Physical Electronics); Peng Lu (General Motors Company); Noel Smith (Oregon Physics); Christopher Szakal (NIST)

TOF-SIMS characterization of materials in the range of several microns from the sample surface has become somewhat routine. Nevertheless, there are practical limitations to the use of ion beam sputtering for probing both organic and inorganic specimens beyond the surface region. Certain matrix components do not sputter well and are susceptible to ion beam-induced molecular damage. This accumulated beam damage gives rise to incorrect molecular distributions. Some matrix components may sputter at a different rate than others which results in a misrepresentation of the elemental and molecular distributions. Finally, the time requirements to achieve uniform (i.e. representative) depth profile analysis under ideal instrumental conditions can become prohibitive. Even under optimized experimental conditions, the efficacy of sputter depth profiling for 3D TOF-SIMS imaging is limited to < 5 μm in the case of a favorable matrix and to < 300 nm in the case of an unfavorable matrix. An alternative approach for 3D TOF-SIMS imaging the interior of a specimen is to utilize FIB milling and sectioning. With FIB milling, the interior of a specimen is revealed to depths of ~ 50 μm within a reasonable analytical timeframe. Additionally, 3D chemical imaging of ~ 10 μm deep volumes may be achieved in the same time it would take to perform a low voltage sputter depth profile. The advantage of the FIB-TOF approach is that the artifacts caused by sputter depth profiling, i.e. differential sputtering and accumulated ion beam damage to matrix molecules, are avoided. The union of successive FIB sectioning and TOF-SIMS analysis cycles to achieve 3D chemical imaging will be discussed and illustrated using inorganic and organic examples.

Tue 6:00PM	AS-TuP-14	Metal Silicide Nanoscale Chemical Characterization with Scanning Auger Microscopy

Dennis F. Paul (Physical Electronics); John S. Hammond (Physical Electronics); David G. Watson (Physical Electronics)

Scanning Auger Microscopy is a powerful compositional analysis technique for surfaces and nanostructures. It is well known that Auger instruments based on full CMA analyzers provide a stable imaging platform and analytical capability that can be successfully applied to a wide range of material systems. Recently a high energy resolution spectroscopy mode that provides enhanced chemical characterization was added to a CMA Auger instrument. This new functionality is integrated with the instrument while maintaining all the existing capabilities and benefits

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associated with the CMA based Auger instrument. The usefulness of this new high energy resolution spectroscopy mode will be demonstrated with detailed chemical information from annealed metal silicide ultra thin films on silicon wafers. Low energy ion beam depth profiling facilitates a chemical state evaluation of the silicide/wafer interface induced by the annealing process. Auger mapping and high energy resolution Auger spectroscopy also characterizes the three dimensional nanostructures formed on the surface and at the interfaces of these metal silicide ultra thin films.		
Tue 6:00PM	SS-TuP-22	XPS Organic Depth Profiling Analysis of Poly-glycidyl Methacrylate Brushes
Saad Alnabulsi (Physical Electronics); John F. Moulder (Physical Electronics); Raphael Barbey (Ecole Polytechnique Fédérale de Lausanne, Switzerland); Harm-Anton Klok (Ecole Polytechnique Fédérale de Lausanne, Switzerland) The application of XPS C_{60} sputter depth profiling to characterize synthesized poly-glycidyl methacrylate (PGMA) brush-like thin film structures will be presented. In contrast to low voltage (250 V) Ar sputtering, C_{60} sputtering with XPS analysis was able to obtain quantitative chemical state information as a function of depth with minimal ion beam induced chemical damage. To minimize sputtering artifacts and improve interface definition, Zalar (azimuthal) rotation and appropriate instrument geometry for C_{60} sputter depth profiling was used for this work. The XPS depth profiles show the chemical changes associated with various solutions applied to these organic films.		
Wed 10:40AM	AS-WeM-9	XPS Comparison of Ar, Coronene, C_{60}, and Ar Gas Cluster Ion Beam Depth Profiling of Polyimide Films
John S. Hammond (Physical Electronics); Takuya Miyayama (ULVAC-PHI, Japan); Noriaki Sanada (ULVAC-PHI, Japan); John F. Moulder (Physical Electronics); Mineharu Suzuki (ULVAC-PHI, Japan); A Takuhara (Kyushu University, Japan) Polyimide thin films have found wide-spread use in many industrial products such as microelectronics and thin film display panels due to their excellent insulating properties, high resistance to heat in manufacturing processes and its excellent flexibility and other mechanical properties. To increase the adhesion of metal films to polyimide substrates, ion beam and plasma surface modification steps are frequently incorporated in the manufacturing processes. It is therefore highly desirable to find a quantitative chemical depth profiling technique to characterize the surface modification layer and the polyimide thin film itself. A comparison of the use of XPS depth profiling of thin polyimide films with Ar, Coronene, C_{60}, and Ar Gas Cluster Ion Beam (GCIB) sputter sources will be presented. The GCIB sputter source produces an $Ar_{2,500}^{+}$ ion beam with user definable incident beam energy. XPS elemental quantification and chemical state spectroscopy reveals that Ar, Coronene and C_{60}, ion sources produce rapid damage of the polyimide with a wide range of ion gun experimental conditions. Optimized conditions for the incident ion beam energy of the GCIB will be presented to provide minimal chemical state damage during the depth profiling of 100 nm thick films. Results will also be presented showing that the GCIB source can be used to remove Ar^{+} induced damage layers.		
Wed 2:20PM	AS-WeA-2	A New Cluster Ion Beam for Advanced Molecular Depth Profiling of Polymers by TOF-SIMS
Takuya Miyayama (ULVAC-PHI, Japan); Shin-ichi Iida (ULVAC-PHI, Japan); Noriaki Sanada (ULVAC-PHI, Japan); Mineharu Suzuki (ULVAC-PHI, Japan); Gregory Fisher (Physical Electronics); John S. Hammond (Physical Electronics); **Scott Bryan (Physical Electronics)** The introduction of C_{60}^{+} as a sputter beam for TOF-SIMS made it possible to acquire molecular depth profiles on a wide variety of polymers. Previous studies by many different groups have demonstrated that not all polymers can be successfully depth profiled and that certain classes of polymers undergo sputter-induced chemical reduction when		

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bombarded by C_{60}^+ ions. If the polymer sputter yield is not high enough, the subsurface sputter-induced damage will accumulate as a function of sputter ion dose and the secondary molecular ion signals will not be stable. A number of different analytical parameters have been previously explored in attempts to improve depth profiling of these difficult polymers including sample temperature, beam energy, and incidence angle. We reported last year that glancing C_{60}^+ incidence angle (76° from surface normal) significantly improved the ability to depth profile polycarbonate and polystyrene, which were previously unsuccessful at a typical incidence angle of 48°. However, even under these optimized conditions, the depth profiles eventually fail after several hundred nanometers due to accumulated sputter damage to the polymer and a concurrent reduction of the secondary ion and sputter yields. In the present study, we report the efficacy of an argon gas cluster ion beam (GCIB) for steady-state molecular depth profiling the same polymer systems. Depth profiles using different GCIB experimental conditions will be reported and compared to C_{60}^+ depth profiles acquired under optimized conditions.		