

# Thursday Afternoon Poster Sessions

## Applied Surface Science

Room: Hall B - Session AS-ThP

### Applied Surface Science Poster Session

**AS-ThP1 Wide-Range Parallel XPS Imaging for Feature Identification.** *T.S. Nunney, A.E. Wright, P. Mack,* Thermo Fisher Scientific, UK

X-ray Photoelectron Spectroscopy (XPS) is a well-established technique for surface-sensitive measurements of the elemental and chemical-state composition of a material. Naturally, there has been a drive to allow imaging methods with XPS, so that chemical distributions can be obtained with high spatial resolution.

One such method, parallel XPS imaging, allows for the simultaneous acquisition of the entire image at a single energy, with high spatial resolution. Conventionally, acquiring such images in small energy steps across a photoelectron peak of interest yields a spectroscopic image, where each pixel contains a spectrum.

Typically, such spectroscopic images are acquired across a single peak region, such as C1s. This minimizes acquisition time, and generates more manageable data sets that are conceptually similar to region spectra in conventional XPS. On a modern XPS instrument, it is possible to acquire a full-range spectroscopic image, where each pixel contains a survey spectrum. This is rarely done, mainly due to acquisition times, and the fact that a point survey spectrum from the imaged area will usually give the elemental composition without need for survey images. However, there are advantages to the method, namely the ability to retrospectively generate spectra from arbitrary parts of the imaged area, to identify composition at any location.

In this presentation, the extension of the parallel XPS imaging technique to wider energy ranges will be discussed, showing how in some situations the use of wide-range spectroscopic imaging can provide information that is difficult or impossible to gain using single-point spectroscopy or region spectroscopic imaging analyses.

**AS-ThP3 Evaluating the Stability of Li-O<sub>2</sub> Battery Components on Cathode/Electrolyte Interface by XPS.** *E. Nasybulin, M. Engelhard, W. Xu, J. Zhang,* Pacific Northwest National Laboratory

The development of rechargeable Li-O<sub>2</sub> batteries is a fast growing research field. Scientific interest is driven not only by high theoretical energy density of Li-O<sub>2</sub> batteries (3,500 Wh kg<sup>-1</sup> including masses of lithium and oxygen) but also by many aspects of material science and engineering involved in the development. At the current stage, Li-O<sub>2</sub> batteries suffer from poor rechargeability because of the wide variety of side reactions between battery components (electrolyte solvent, electrolyte salt, and electrode materials – Li anode, cathode substrate, binder, catalyst) and reduced oxygen species (O<sub>2</sub><sup>•</sup>, O<sub>2</sub><sup>2-</sup>) generated during the discharge. These side reactions predominantly happen at the cathode/electrolyte interface simultaneously with the reversible formation/oxidation of Li<sub>2</sub>O<sub>2</sub> during the discharge/charge processes. Unlike Li<sub>2</sub>O<sub>2</sub>, the side products are difficult to decompose and accumulate with cycling forming an insulating layer at the interface and eventually leading to the battery failure. Therefore, analysis of side products is important to evaluate the stability of battery components and may suggest new robust materials for the application in Li-O<sub>2</sub> batteries. Considering the side products form only a thin layer on the interface, characterization of these products by bulk methods is problematic. X-ray photoelectron spectroscopy (XPS) is a powerful surface sensitive technique which is probably the most suitable for the analysis of such interfaces. In the present study, XPS is applied to evaluate the stability of various components of Li-O<sub>2</sub> batteries, including electrolyte solvents, electrolyte salts, polymer binders and organic catalyst on the surface of carbon-based cathodes during the discharge process of the Li-O<sub>2</sub> batteries. With the support from other techniques, the most stable components are identified and suggested for the rechargeable Li-O<sub>2</sub> batteries. Decomposition pathways are proposed for a number of components based on their decomposition products. Contributions from the degradation of various battery components to the overall failure of Li-O<sub>2</sub> batteries are estimated. It is demonstrated that the chemical and electrochemical stability of the components has a drastic effect on the discharge capacity and cycling stability of Li-O<sub>2</sub> batteries. Details of this study will be reported in the presentation.

**AS-ThP4 Surface Modification of Multiferroic BiFeO<sub>3</sub> Ceramic by Argon Sputtering.** *P. Wang, M. Guttag,* Bradley University, *C. Tu,* Fu Jen Catholic University, Taiwan, Republic of China

Films fabricated by sputtering deposition are extensively used in semiconductor, optical and optoelectronic industries. Since the sputtering is the key to physically deposit the films onto substrates, its effect on the target materials is needed to investigate in order to fabricate films successfully. In this study, multiferroic bismuth ferrite, BiFeO<sub>3</sub> (BFO) with 5 mole% BaTiO<sub>3</sub> target was sputtered by using 3 keV argon ions continuously after various time intervals. The X-ray Photoelectron Spectroscopy (XPS) was applied to examine the cleanliness and the chemical environment of the elements on the sample surface after each sputter time interval. The carbon contaminant was almost completely removed after 5120 s sputtering, but the sputtering induced metallization of the bismuth and two-component oxygen spectra were also observed. It was found that the oxidation states of bismuth from dominant 3+ state changed to equally weighted 3+ state and 0 state. The changes of the valence electrons of bismuth induced by the argon sputtering on the BFO target inevitably alter the film compositions deposited onto the substrate; however, it was found that the non-stoichiometric BFO films can be corrected by sputtering under partial oxygen pressure *via* the re-oxidation of bismuth metal.

**AS-ThP5 In Situ Plasma Cleaning of Samples Prior to XPS and ToF-SIMS Analysis.** *V. Smentkowski, H. Piao,* General Electric Global Research Center

Most samples submitted for surface analysis using Auger electron spectroscopy (AES), x-ray photoelectron spectroscopy (XPS) and/or time of flight secondary ion mass spectrometry (ToF-SIMS) that are generated in an industrial laboratory are exposed to ambient air, or harsher conditions. The spectra of the as received material is often dominated by carbon and oxygen or hydrocarbon species when analyzed by AES/XPS or ToF-SIMS respectively. These surface contaminants frequently attenuate the signal from the underlying surface of interest and can complicate accurate analysis of the sample. Such surface contaminants are often removed from samples using in-situ ion beam sputtering however sputtering is an energetic process which can modify the surface of interest. In this work, we demonstrate the benefits of using in-situ, low power, RF plasmas to clean a variety of samples for both XPS and ToF-SIMS analysis.

**AS-ThP6 Spectral Chemical State Imaging with High Spatial Resolution Scanning Auger.** *D.F. Paul,* Physical Electronics Inc.

Recent improvements of field emission scanning Auger instruments have led to the ability to provide elemental imaging of surfaces with a spatial resolution better than 8 nm. The PHI 710 now provides the capability to combine high energy resolution spectra with high spatial resolution chemical state imaging with a CMA analyzer. The system software also provides LLS separation of different chemical states from the Auger imaging data.

A semiconductor structure with multiple silicon chemical states will be presented. The 0.1% energy resolution spectra for silicide, silicon, and silicon oxynitride are extracted from the scanning Auger image. These basis spectra are then used to create the different chemical state images. The resulting image overlays demonstrate the ability of the CMA analyzer to image different chemical states at high energy resolution without topographical artifacts.

**AS-ThP7 Laser Induced Breakdown Spectroscopy for Surface Mapping of Thin Polymer Films.** *C.Y. Chou,* National Taiwan University, Taiwan, Republic of China, *P.R. Chou,* Chinese Culture University, Taiwan, Republic of China, *J. Lee,* Optimization Solutions Asia Engineering Co. Ltd., Taiwan, Republic of China, *R.B. Lin,* Chinese Culture University, Taiwan, Republic of China, *C.C. Hsu,* National Taiwan University, Taiwan, Republic of China

Laser Induced Breakdown Spectroscopy (LIBS) is a technique for elemental analysis on inorganic and organic materials. It uses a pulsed laser beam to ablate the surface of the target materials and generate plasma. By analyzing the optical emission spectra emanating from the plasma, information related to the ablated material composition can be obtained. The key features for LIBS include fast analysis, simultaneous multiple element detection, analysis under ambient atmosphere, and no or very little need for sample preparation. In this presentation, LIBS analysis on thin film samples is performed with the goal of understanding its capability to detect polymer thin film materials and to perform surface mapping. The LIBS system (Insight, TSA) is equipped with a pulsed laser and a charge-coupled device (CCD). LIBS systems equipped with 266 and 1064 nm laser sources are tested under air and argon atmosphere. The polymer films tested are

fluorocarbon (FC) thin films coated on silicon wafer and glass substrates. Results show that when the 1064 nm system is used, clear C- and F-emissions can be observed for FC coated substrates with a coating thickness down to 100 nm. While using the 266 nm laser, rather poor signal to noise ratio is obtained for F- and C-emissions. Substrates patterned with 500 nm wide stripes FC thin films are then tested to obtain spatially resolved information for the patterned surfaces. By using the 1064 nm laser source, spatial resolution of approximately 100 nm can be obtained. This demonstrates the capability using LIBS as the spatially-resolved surface mapping of polymer films for thin films. This work was supported by National Science Council of Taiwan, the Republic of China (101-2221-E-002-163-MY2)

**AS-ThP8 Variables Affecting Fabric Water-Repellency: Enabling Property Correlations through the use of Secondary Ion Mapping Coupled with Multivariate Statistical Analysis.** *K.G. Lloyd, S. Brown, L. Zhang, J.R. Marsh, D.E. Davidson*, DuPont Corporate Center for Analytical Sciences, T. Madeleine, DuPont

Water and soil repellency confer a distinct advantage to apparel. A number of processing steps are required to produce water-repellent fabrics. The original fiber spin finish is needed for fabric weaving but then must be removed (though rarely completely) prior to water-repellent treatment. The composition of water-repellent formulations varies among different formulators and even from a single formulator over time. In addition to fluorocarbons with different polymer backbones and different fluorocarbon tail lengths/distributions, water-repellent formulations may also include so-called "extenders" or performance enhancers. Drying and curing steps are typically required.

Surface characterization plays a critical role in understanding water repellency. This presentation will focus on the surface analytical methodologies developed to help correlate formulation and processing variables to repellency performance. These include the use of multivariate statistics with ToF-SIMS mapping data to quantify fluorocarbon coverage as well as to understand the effect of "uncoated" surface character. These results will be combined with fabric surface energetics measurements to yield a more complete picture of the fabric treatments.

**AS-ThP9 Enhanced TOF-SIMS Analysis of Polymers and Biological Samples.** *R. Price, G.L. Fisher, S.R. Bryan, J.S. Hammond*, Physical Electronics Inc., *I. Ishizaki, S. Iida, T. Miyayama*, ULVAC-PHI, Inc., Japan  
Five synergistic performance characteristics of the new PHI nanoTOF to improve the analysis of polymer and biological samples will be discussed. These desired characteristics are the ultimate spatial resolution, mass resolution, mass range, insensitivity to topographical artifacts and ultimate abundance sensitivity. A new LMIG has been developed which can simultaneously achieve a typical spatial resolution of 400 nm and a mass resolution greater than 10,000 m/Δm. When combined with the nanoTOF analyzer, topographical features within a depth of field of 200 μm can be imaged. To extend the molecular sensitivity beyond the traditional static SIMS limit of 1013 incident ions/cm<sup>2</sup>, the use of voxel analysis can be used. For voxel analysis, an image is acquired to the static limit, followed by the removal of the damaged surface layer with Gas Cluster Ion Beam (GCIB) source, followed by additional cycles of LMIG acquisition and GCIB damage removal. By integrating signal intensities as a function of GCIB depth of removal, three dimensional voxels of data can be acquired with much higher molecular sensitivities than data only acquired to the static SIMS limit.

Data from a mixed phase polymer sample, micron sized organic contamination features on a failure analysis sample and images of biological samples will be discussed. Retrospective quantitative line scans and spectra from these samples will demonstrate the advantages of these new capabilities for TOF-SIMS polymer and biological sample analyses.

**AS-ThP12 XPS and ToF-SIMS Sputter Depth Profiling of OLEDs using Ar Cluster Ion Sources.** *M. Bruns, K. Peters, P. Scharfer, W. Schabel*, Karlsruhe Institute of Technology, Germany, *H. Hummel*, Philips Technologie GmbH, Germany, *T.S. Nunney*, ThermoFisher Scientific, UK, *E. Tallarek*, Tascon GmbH, Germany, *S. Kayser*, ION-TOF GmbH, Germany

Research on organic light-emitting diodes (OLEDs) has gained much attention due to the potential for cheap and ultrathin illumination sources with high color range. In multilayer OLEDs the carrier injection efficiency from the electrodes into the light emitting layer is improved by layers for hole or electron transport and blocking. Vacuum evaporation is the standard method to produce precisely defined interfaces, but it is an expensive process with high material usage. Alternatively, the wet chemical processing has advantages in production cost, deposition rate and area, but shows problems with the intermixing of the subsequently coated functional layers. The specific nature of small molecules used for OLEDs with their

high mobility for diffusion in combination with low dry film thicknesses of only a few nanometers is challenging. For a better understanding of the physical limitations of liquid-phase processed multilayer OLED structures, the possibility to characterise the material mixing between two layers during coating and drying, and the comparison to evaporated layers is crucial.

The present study focusses on the surface analytical characterization of OLED multilayer films using X-ray photoelectron spectroscopy (XPS) and complementary time-of-flight secondary mass spectrometry (ToF-SIMS). In the case of (bio-) organic materials, both methods provide the chemical composition of the topmost layer, XPS mostly in a non-destructive manner. However, information on the in-depth distribution of the constituents in multilayer OLED systems, e.g. to prove chemistry and sharp interfaces, is unavailable via sputter depth profiling when using monoatomic Ar<sup>+</sup> (XPS) and Cs<sup>+</sup> (ToF-SIMS) ion sources for material erosion. Here the high fluence of even low energy monoatomic ions with a projected range in all cases greater than the XPS/ToF-SIMS sampling depth causes decomposition of the organic material. But since the recent introduction of high mass Ar cluster ion sources for both XPS and ToF-SIMS, enabling sputter depth profiling of organic materials while preserving the chemical/molecular information, this drawback can be overcome [1,2]. We present quantitative in-depth information on the desired OLED structures and, moreover, compare results achieved from monoatomic and cluster ion source depth profiling.

*V. S. Smentkowski, G. Zorn, A. Misner, G. Parthasarathy, A. Couture, E. Tallarek and B. Hagenhoff*, J. Vac. Sci. Technol. A 31 (2013) 030601.

*P. J. Cumpson, J. F. Portoles, N. Sano, and A. J. Barlow*, J. Vac. Sci. Technol. B 31 (2013) 021208.

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**AS-ThP13 Depth Profiling of OLED and OPV Materials by Cluster Ion Beams.** *K.D. Bomben, J.S. Hammond, J.F. Moulder, S.S. Alnabulsi, S.N. Raman*, Physical Electronics Inc., *N.C. Erickson, R.J. Holmes*, University of Minnesota

Cluster ion beam technologies, in particular the use of C<sub>60</sub> and Ar gas cluster ion beams (GCIB), are increasingly being used for the depth characterization of organic materials to provide information that is not available from monoatomic ion beams such as Ar<sup>+</sup>. For surface analysis applications, these cluster sources are used for a wide range of organic materials, including multi-layer organic thin films and organic light emitting diodes (OLEDs), including metal capped devices.

Improvements in the efficiencies for OLED structures have recently focused on the incorporation of more effective organic materials and the on the development of novel structures for arranging these organic materials. Multi-layer devices, graded composition devices, and novel electrical contact layers to the organic materials are all being rapidly developed. The need for analytical techniques that allow the elucidation of the organic thin film structure as a function of device fabrication and lifetime studies is extremely important.

In combination with GCIB sputtering, XPS and TOF-SIMS are being used for quantitative chemical as well as molecular depth profiling techniques for OLED structures. The ability to accurately identify the chemistry at an interface using a co-sputtering protocol involving conventional argon ions and an argon cluster will be discussed. Quantitative compositional depth profiling of graded composition multilayer OLED films and other OPV devices will be demonstrated.

**AS-ThP15 Selective Chemistry for the Atomic Layer Deposition (ALD) of Alumina Oxide on Silicon Surfaces.** *L. Guo, F. Zaera*, University of California, Riverside

In search for a way to modify SiO<sub>2</sub>-based surfaces to prepare them for selective film deposition, silylation and UV/ozonolysis treatments were tested on different silicon oxide and ultra-low k SiCOH surfaces. The chemical behavior of surfaces treated with hexamethyldisilazane (HMDS) and octadecyltrichlorosilane (ODTS), two common silylation agents, was first investigated by contact angle measurements and attenuated total reflection infrared absorption spectroscopy (ATR-IR). Silylation with agents such as these are expected to block the surface hydroxyl sites believed to act as nucleation sites for film growth. Addition of the silanes was confirmed by ATR, after which the contact angle of the silicon surfaces became larger. This indicates an increase in hydrophobicity, which means that most if not all of the surface hydroxyl groups become covered and unavailable for atomic layer deposition (ALD) film growth. These and other hydrophobic surfaces were then treated with a combination of ozone and ultraviolet (UV) light for up to 45 min in order to return their hydrophilicity and to reactivate them for film deposition. Indeed, these treatments led to a decrease in contact angle with exposure time, which was varied from 5 to

35 min; no further changes in the contact angle were seen after exposures for more than 35 min. The silane-coated silicon samples exposed to the silylation agents and to the UV/ozone treatment are currently being tested for the selective ALD of metal oxide films.

**AS-ThP16 Analysis of Doped Amorphous Carbon Film for Heat-assisted Magnetic Recording Application, R.Y. Zheng, R. Ji, L. Lu, H.L. Seet, Data Storage Institute, Singapore**

Heat-assisted magnetic recording (HAMR) uses a laser-magnetic head integrated system to rapidly heat a localized recording area of the medium above its Curie temperature in order to reduce its coercivity below that of the applied magnetic field during the recording process.<sup>1,2</sup> Unlike perpendicular recording, HAMR is not limited by the superparamagnetic effect associated with magnetic particle instability and low signal-to-noise ratio.<sup>2</sup> However, localized laser heating may affect the thermal stability of the protective carbon coating on the hard disk.<sup>1,2,3</sup> To examine the effect of heating on carbon film stability, three types of a-C films of 5nm thickness have been studied; (1) single layer a-CH film (2) single layer a-CN film and (3) double layer a-CN/CH film. This paper discusses the relationship between thermal heating and structural evolution of the carbon films. XPS was employed to investigate the sp<sup>2</sup> and sp<sup>3</sup> carbon formation related to heating. The variation in sp<sup>2</sup>/sp<sup>3</sup> content and the dispersion of D and G peaks in Raman spectra both prove that there is a structural change in the carbon films after heat. Differences in sp<sup>2</sup>/sp<sup>3</sup> ratio shows that the carbon structure of a-CN/CH film is thermally more stable than a-CH and a-CN films. TOF-SIMS results reveal that the top a-CN capping layer of the double layer a-CN/CH film structure is able to preserve the C-H bonding within the a-CH under layer. This result in the carbon structure of double layer a-CN/CH film exhibiting better thermal stability compared to single layer a-CH film.

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**AS-ThP18 Application of Dye-Sensitized Solar Cells using ZnO Nanoparticles and Nanorods, S.-H. Nam, J.-H. Boo, B. Hong, Y. Kim, Sungkyunkwan University, Republic of Korea**

One-dimensional metal oxide nanorods show improved electrical and optical properties in the photoelectrodes of dye-sensitized solar cells (DSSCs). They can provide straight moving paths for electrons and reduced the electron hole recombination. In this study, ZnO nanoparticles and nanorods were synthesized by the spray-pyrolysis and thermal evaporation method. The effect of the ZnO nanostructure morphology on the photovoltaic performance of a DSSC is investigated. The ZnO nanoparticle-based solar cell are 3.74 mA/cm<sup>2</sup> and 0.771 V, while the ZnO nanorod-based solar cell has Jsc of 2.48 mA/cm<sup>2</sup> and Voc of 0.751 V. This difference could be due to the difference in absorption behavior and surface area between the two types of ZnO nanostructures. At the IPCE data, the recombination of the nanoparticle/electrolyte interface occurs much lower than that at the nanorods/electrolyte interface.

**AS-ThP19 Generation of White Light from Sr<sub>2</sub>SiO<sub>4</sub> Doped with Lanthanides, M.A. Tshabalala, O.M. Ntwaeaborwa, H. Swart, University of the Free State, South Africa**

In recent years, the study of the synthesis and characterization of white light emitting phosphors for use in white light emitting diodes (LEDs) has generated attention worldwide. In white light LEDs, white light can be generated by combination of light of three primary colors (red, green and blue) emitted from different LED chips<sup>1</sup> or combination of blue LED with yellow-emitting phosphor materials.<sup>2,3</sup> The problems with these traditional white LEDs is that the yellow YAG:Ce<sup>3+</sup> phosphor has been reported to show high thermal quenching and poor colour rendition, and that the efficiency of the blue emission is often affected by re-absorption by the red or green phosphor in the three converter system. It is important to find a phosphor that can be excited under near-ultra-violet and the blue region<sup>3</sup>. In recent studies it has been established that white light can be generated by doping one or more activator(s) in one matrix. For example, in this study white photoluminescence was generated when Sr<sub>2</sub>SiO<sub>4</sub> single doped with Dy<sup>3+</sup> or co-doped with Tb<sup>3+</sup> and Eu<sup>3+</sup> was excited using a monochromatized xenon lamp. The structure, particle morphology, chemical composition and oxidation states, photoluminescence (PL) and decay properties of the phosphor were analyzed using X-ray diffraction (XRD), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy and PL spectroscopy, respectively. The XRD patterns showed that a monoclinic phase of Sr<sub>2</sub>SiO<sub>4</sub>

was crystallized. The decay characteristic data showed that the phosphor consist of single exponential decay curves. The X-ray diffraction data confirmed that.

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**AS-ThP21 Thermally-Induced Evolution of Hydrogenated Amorphous Carbon Surfaces, R.W. Carpick, F. Mangolini, J. Hilbert, J.R. Lukes, University of Pennsylvania**

Hydrogenated amorphous carbon (a-C:H) thin films are amongst the strongest, smoothest, and most lubricious coatings in existence. The impressive properties of these materials have resulted in their use in a wide range of applications. In particular, thin a-C:H films are employed as lynchpin materials to protect computer hard disks from corrosion and wear. Even though amorphous carbon-based materials have been studied for more than two decades, there is significant ambiguity regarding the mechanisms by which they transform in response to temperature or other energetic inputs. Quantifying the energetics and specifying the physical pathways of thermally-induced structural transformations have proven difficult. Progress has been limited by the challenges associated with the experimental investigation of the structure and bonding configuration of these materials in their thin film configurations, calling for the development of advanced analytical methods.

In this work, new insights into the thermally-induced structural evolution of a-C:H were gained by coupling experiments and molecular dynamics (MD) simulations. A new experimental methodology for quantitatively determining the bonding configuration of carbon in the near-surface region of a-C:H thin films was developed on the basis of X-ray photoelectron spectroscopy (XPS) and X-ray induced Auger electron spectroscopy (XAES) and allowed the *in situ* XPS and XAES investigation of the thermally-induced structural evolution of a-C:H. Upon high vacuum annealing, three thermally-activated processes with an assumed Gaussian distribution of activation energies with mean value  $E$  and standard deviation  $\sigma$  occur in a-C:H: a) ordering and clustering of sp<sup>2</sup>-hybridized C ( $E=0.18$  eV;  $\sigma=0.05$  eV); b) scission of sp<sup>3</sup> C-H bonds with formation of sp<sup>2</sup>-hybridized C ( $E = 1.7$  eV;  $\sigma = 0.5$  eV); and c) direct transformation of sp<sup>3</sup>- to sp<sup>2</sup>-hybridized C ( $E = 3.5$  eV;  $\sigma = 0.5$  eV). This first XPS-based study both demonstrates the low absolute energy barrier for clustering of the sp<sup>2</sup> phases, and indicates that hydrogen enables conversion to sp<sup>2</sup> hybridization in these films.

The experimental results were compared with the outcomes of MD simulations performed using the adaptive intermolecular reactive bond order potential. The atomic composition was chosen to match experiments, and the resulting structure was relaxed to the measured density. This enabled the direct visualization of the structure of a-C:H and its evolution as a function of temperature and time. We will discuss the comparison between the simulation and experimental results, emphasizing the insights gained from the fully atomistic picture provided by the atomistic simulations.

**AS-ThP22 Contact-free Pyroelectric Measurements using X-ray Photoelectron Spectroscopy, H. Cohen, D. Ehre, The Weizmann Institute of Science, Israel**

A novel application of x-ray photoelectron spectroscopy (XPS) is presented, measuring pyroelectricity in a non-contact mode.<sup>1</sup> We demonstrate, as a proof of concept, how the XPS-derived surface potential<sup>2,3</sup> of Lithium Tantalate crystals provides a direct and simple probe of the desired property, free of all top-contact related difficulties. An experimentally challenging feature, the increase in Lithium Tantalate spontaneous polarization under cooling, is thus evaluated, proposing insight on the roll of surface contaminants and the control over trapped surface charge at the XPS vacuum environment. Our approach can be extended to other non-contact probes, as well as to measuring additional electrical properties, such as piezoelectricity and ferroelectricity.

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