# Tuesday Morning, October 20, 2015

## Applied Surface Science
## Room: 212D - Session AS+NS-TuM

### Chemical/Molecular Information from Sub-micron Features and Materials
**Moderator:** Carl Ventrice, Jr., SUNY Polytechnic Institute, David Carr, Physical Electronics USA

8:40am **AS+NS-TuM3 ASSD 30th Anniversary Speaker: Defect Detection and Characterization in Wafer Processing and Magnetic Storage Technologies – Then, Now and (maybe) the Future.**, ***Christopher Brundle***, C R Brundle and Asociates **INVITED**

Some 30 years ago defects ("particles") in wafer processing were unacceptable for sizes in the um range. Today the specification is 23nm and will soon be 19nm. These numbers are, of course, directly related to the ever decreasing dimensions of semiconductor devices. This paper gives a historical overview of the evolution of the techniques used in defect detection and characterization for both Development and Manufacturing over this period, and what might be needed in the future.

In Magnetic Storage key dimensions have decreased at a similar pace and similar defect and quality control issues obtain. Some of these will also be discussed, if there is time.

Examples are presented where possible, but there is an understandable difficulty in obtaining release for real examples of defects concerning current forefront technology!

9:20am **AS+NS-TuM5 Characterisation of Glass-To-Metal Interfaces using FIB and STEM**, ***Paul Yates***, University of Surrey, UK

Components needing electrical feed through seals are frequently made with glass-to-metal seals and have been for many years. They are often made with stainless steel and silicate glasses but, in order to save weight or for biomedical uses, titanium components are sometimes required. Silicate free glasses are required due to the deleterious reaction that occur between titanium and silicate glasses. The reactions in these systems are not fully understood. When characterising the interfaces and assessing interface quality the standard approach is to use cross sections and characterise with scanning electron microscopy and energy-dispersive x-ray spectroscopy. Although this can reveal micrometer scale processes it can not reveal the nano scale reactions that determine the bonding across the interface in many cases. In this work focussed ion beam milling and scanning transmission electron microscopy are used to attain nano scale information about selected areas of the interface between titanium and a strontium boroaluminate glass-ceramic. Additionally, reactions between the glass-ceramic and Kovar (Fe-29Ni-17Co), a common glass sealing alloy, are characterised. Oxidation of the Kovar surface creates an oxide, characterised with x-ray photoelectron spectroscopy and x-ray diffraction, that improves bonding across the interface compared to the native oxide.

9:40am **AS+NS-TuM6 X-ray Structural Analysis of Self-assembled Nano-Dielectrics**, ***Li Zeng***, *A. Walker*, Northwestern University, *R. Turrisi*, University of Milano-Bicocca, Italy, *M.C. Hersam, T.J. Marks, M.J. Bedzyk*, Northwestern University

Organic thin-film transistors (OTFTs) are viewed as the new generation thin-film transistors (TFT) for future low-cost, printable, structural flexible electronics, and related processable solution-based organic and inorganic semiconductors. However, one major limitation of OTFTs is that the organics semiconductors exhibit relatively low carrier mobility, which requires high operating voltage in order to achieve an operational drain current. One route to reduce the operation voltage is to increase the capacitance of the dielectric layer as the drain current increases linearly with respect to the dielectric capacitance for constant operating voltages and channel dimensions. A class of materials called self-assembled nano-dielectrics (SAND) with phosphoric acid-functionalized organic precursors sandwiched between ultrathin layers of high-*k* inorganic oxide materials has been synthesized and applied in the TFT field. These materials show exceptionally large capacitance, excellent insulating properties, and are also suitable for ambient atmosphere fabrication. The hybrid nature of these materials utilizing the distinct properties of both the organic and inorganic components can be incorporated into the low-operating voltage semiconductor-based OTFTs to enhance the performance.

Despite the impressive performance and flexibility of SANDs, some fundamental aspects of dielectric behavior remain unexplored. Particularly, the behavior of the $Br^{-}$ counteranions that are paired with the phosphonic acid-based -electron (PAE) cationic building blocks are poorly understood. It is believed that the location, distribution of the $Br^{-}$ counteranions, as well as their response to applied AC and DC electric fields, are critical to the behavior of the dielectric in device-like environments. Therefore, long-period X-ray Standing Wave (LP-XSW), which is a powerful technique sensitive to heavy atom distributions, was used to characterize a three-layer SAND structure deposited on synthetic Si/Mo multilayer substrates. The elemental distributions of Br and reference elements were extracted from the analysis of XSW data. These accurate measurements are important for better understanding counteranion distributions, charge transport, dipole-semiconductor interactions, and future device modeling and engineering.

11:00am **AS+NS-TuM10 Multimodal Imaging for Physical and Chemical Surface Characterization using a Combined Atomic Force Microscopy-Mass Spectrometry Platform**, ***Olga Ovchinnikova***, Oak Ridge National Laboratory **INVITED**

The functionality of materials is largely determined by the mechanisms that take place at sub-micron length scales and at interfaces. In order to understand these complex material systems and further improve them, it is necessary to measure and map variations in properties and functionality at the relevant physical, chemical, and temporal length scales. The goal of multimodal imaging is to transcend the existing analytical capabilities for nanometer scale spatially resolved material characterization at interfaces through a unique merger of advanced scanning probe microscopy, mass spectrometry and optical spectroscopy. Combining atomic force microscopy (AFM) and mass spectrometry (MS) onto one platform has been demonstrated by our group as a method for high resolution spot sampling and imaging of substrates. To advance this basic approach and to expand its capabilities we now have incorporated Band-Excitation (BE) to allow us to measure nanomechanical properties of a sample by measuring the contact resonance frequency shift. In this presentation, I will discuss the benefits of a multimodal imaging system and demonstrate our results for polymeric systems, biological plant and animal tissue, and bacterial colonies. I will also talk about future developments to incorporate spectroscopic measurements into the platform.

This work was supported by the Division of Chemical Sciences, Geosciences, and Biosciences, Office of Basic Energy Sciences, United States Department of Energy. ORNL is managed by UT-Battelle, LLC for the U.S. Department of Energy under contract DE-AC05-00OR22725.

11:40am **AS+NS-TuM12 Understanding the TERS Effect with On-line Tunneling and Force Feedback Using Multiprobe AFM/NSOM with Raman Integration**, *A. Lewis*, The Hebrew University of Jerusalem and Nanonics Imaging Ltd, Israel, ***Rimma Dekhter***, *P. Hamra, Y. Bar-David, H. Taha*, Nanonics Imaging Ltd, Jerusalem, Israel

Tip enhanced Raman scattering (TERS) has evolved in several directions over the past years. The data from this variety of methodologies has now accumulated to the point that there is a reasonable possibility of evolving an understanding of the underlying cause of the resulting effects that could be the origin of the various TERS enhancement processes.

The objective of this presentation is to use the results thus far with atomic force microscopy (AFM) probes with noble metal coating, etching, transparent gold nanoparticles with and without a second nanoparticle [Wang and Schultz, ANALYST 138, 3150 (2013)] and tunneling feedback probes [R. Zhang et. al., NATURE 4 9 8, 8 2 (2013)]. We attempt at understanding this complex of results with AFM/NSOM multiprobe techniques. Results indicate that TERS is dominated by complex quantum interactions. This produces a highly confined and broadband plasmon field with all k vectors for effective excitation. Normal force tuning fork feedback with exposed tip probes provides an excellent means to investigate these effects with TERS probes that we have shown can circumvent the vexing problem of jump to contact prevalent in conventional AFM methodology and permit on-line switching between tunneling and AFM feedback modes of operation.

12:00pm **AS+NS-TuM13 High Resolution CREM for Electrical Characterization of Thin Oxide Layers**, ***Hagai Cohen***, *A. Givon*, Weizmann Institute of Science, Israel

The chemically resolved electrical measurements technique (CREM) has already been proven very useful in studies of nanometric layered structures. CREM exploits the chemical contrast across a studied system to probe the local, domain specific, electrostatic potential in a non-contact manner. As such, its spatial resolution is usually determined by the studied structure itself, other than the probe size; a fact imposing severe limitations when nm, or even sub-nm, resolution is requested. In the present work we show that this inherent limitation can be overcome. Improved CREM resolution is established, with which a principal progress is demonstrated in the access to fine details of the electrical properties of nanometric $SiO_2$ layers grown on SiC substrates.

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