SIMS Solutions in Materials and Life Sciences
Room Great Lakes B - Session SS+DI-MoA3

Industrial Applications II

Moderators: Cody Cushman, Corning Incorporated, **Teruaki Kikuchi**, SONY Semiconductor Manufacturing

2:00pm **SS+DI-MoA3-1 Keynote Industrial Talk: Correlative Microscopy and Data Analysis for Semiconductor Technology Applications***, **Jean-Paul Barnes**, C. Guyot, P. Hirchenhahn, N. Gauthier, M. Moreno, T. Maindron, Y. Mazel, E. Nolot,* CEA-Leti, France*; A. Priebe,* EMPA (Swiss Federal Laboratories for Materials Science and Technology), Switzerland*; B. Gautier,* CNRS, France*; A. Tempez, S. Legendre,* HORIBA France*; G. Fisher,* Physical Electronics USA **INVITED**

The increasingly complex structures and large variety of materials used in modern nano and opto-electronic devices drives the need to develop new approaches for their characterization. To obtain the desired information it is often necessary to combine several techniques to acquire reliable information. Ideally, this should be from exactly the same spot on a specimen. This can be challenging both in terms of measurement protocols, but also in the data treatment required to correlate data sets from different techniques and/or modalities. In an applied research or industrial environment, the ability to give fast feedback is a great advantage in materials and process development. It is thus important to have access to a wide range instruments and techniques that are complementary in their capabilities. This presentation will address developments in TOF-SIMS and tandem MS analysis for applications from semiconductor technology to display technology and the importance of using several techniques such as scanning probe microscopy, X-ray tomography, TEM-EDX, XPS and plasma profiling time-of-flight mass spectrometry. The importance of sample preparation to enable multi-technique studies is also critical and several examples will be given involving focused ion beam milling, wedge crater preparation and transfer between instruments under a protected environment (vacuum or inert gas).

Part of this work, carried out on the Platform for Nanocharacterisation (PFNC), was supported by the “Recherches Technologiques de Base” program of the French National Research Agency (ANR).

2:40pm **SS+DI-MoA3-5 Basic Evaluation and Impurity Analysis in OLED Devices with New Ion Guns for Dynamic-SIMS***, **Tomomi Ohashi**, S. Inayoshi,* ULVAC, Inc., Japan*; D. Sakai, T. Miyayama,* ULVAC PHI, Inc., Japan

ULVAC-PHI developed new ion guns that can narrow the diameter of the beam. These have been installed in our own D-SIMS equipment (ADEPT-1010). We report that the results from the basic evaluations and impurity analyses of OLED devices.

We analyzed small areas (100 μm x 250 μm) of patterned samples. Samples were Au/Pt/Ti/Si wafers as multilayer films. These were compared before and after annealing (Fig. 1①). It was observed that Au diffused toward the Pt film in the sample after annealing. The results of measuring larger areas (Fig.1②) were equivalent to the results of measuring the smaller areas. Therefore, it has been determined that measuring smaller areas were possible without being affected by the surrounding area.

It is known that the OLED device lifetime is shortened if impurities are mixed in during their production. We evaluated the intensity and the in-plane distribution of impurities in OLED devices, especially focusing on halogen elements in the organic layers. We prepared two samples. One is the sample ※1 with a short lifetime and the other is the sample ※1 with a long lifetime. The device has a light-emitting area of 2.3 mm in diameter. The luminous area was divided into five regions (top, bottom, left, right, and center), and each location was measured multiple times. Fig. 2 shows the results at the center of the sample. Fluorine was detected from devices with shorter lifetimes, but there was no difference in chlorine intensity. Similar results were obtained from other regions. To evaluate reproducibility, we compared the Coefficient of Variation (CV) of the integrated intensity values of fluorine (m/z = 19) from 250 s to 450 s. The CV of the center position was 0.090, and the overall CV ranged from 0.050 to 0.17. Although there was some variation, the reproducibility was generally good. These results suggest that one of the reasons for the shorter lifetime of OLED devices is the presence of fluorine in the organic layer.

References:[1] K. Suzuki et al. Proc. of the 33th Meeting of Japan OLED Forum, (2021), p. 13.

3:00pm **SS+DI-MoA3-7 Sample Processing by Bi-FIB for TOF-SIMS Imaging of Buried Interfaces***, **Shin-ichi Iida**,* ULVAC-PHI, Inc., Japan*; G. Fisher,* Physical Electronics*; T. Miyayama,* ULVAC-PHI, Inc., Japan

Focused ion beam (FIB) is commonly used as a standard machining technique in failure analysis, quality control, reverse engineering, material research, etc., for the samples having micro- and nanostructures. FIB combined with time-of-flight secondary ion mass spectrometry (TOF-SIMS), so-called FIB-TOF, has attracted attention as a method to determine the three-dimensional (3D) chemical distributions of complex samples. In general, a highly focused Ga^+ ion beam is used for FIB, however, the FIB-milled area is limited and it was difficult to expand the Ga-FIB to hundreds of micron length scale sample fabrication. In order to overcome the drawback, we proposed Bi-FIB approach for large scale sample cross-sectioning. Although the possibility of Bi-FIB has been reported, there were almost no performance examinations as well as practical applications. In this study, therefore, the authors summarize the comparison of milling rate and milling damage between Ga-FIB and Bi-FIB. As a result, it was found that Bi-FIB can provide higher milling rate with thinner milling damage. Finally, the Bi-FIB approach was applied to the interfacial analysis of all-solid-state battery (ASSB) material, because the functionality of ASSBs strongly depends on the solid/solid interface. With this approach, the detailed chemical distributions at the interface was discovered, leading to the better understanding of battery behaviors.

3:20pm **SS+DI-MoA3-9 HDR of SIMS Data***, **Henrik Arlinghaus**, D. Rading, E. Niehuis,* IONTOF GmbH, Germany

The number of secondary ions generated during a ToF-SIMS experiment is dependent on numerous factors. While the operator is able to configure the instrument to optimize the yield, many factors such as the ionization probability, differences in molecular species concentrations, or the (in)homogeneity of the spatial distribution within the sample cannot be changed. Challenging samples may therefore run into the limits of the dynamic range of a modern SIMS instrument, which is around five orders of magnitude. When this is the case the operator must find a compromise which limits the noise in low intensity signals and areas while minimizing oversaturation of high intensity signals or areas.

In photography one approach to overcome similar limitations is the use of "High Dynamic Range", or HDR photography. This approach takes multiple images in short succession with varying exposure times and then fuses these together to generate a single composite image.

Previously we had demonstrated the possibility of acquiring multiple datasets during a single acquisition pseudo simultaneously, with each dataset having been acquired using different instrument parameters, while minimizing the impact of changes in the sample or the environment, using multiplexing[1]. In this paper, we continue that work by demonstrating that it is possible to generate combined profile and images for substances of interest using a HDR-like algorithm from such a dataset, reducing noise within low intensity areas, and saturation effects in high intensity areas, simplifying data interpretation.

[1]: Multiplexing ToF-SIMS acquisition modes to improve information yield

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