Micromechanical testing | Electrical nanoprobing | Correlated AFM-SEM imaging | SEM signal acquisition and processing

Workshop on In-Situ Microscopy Solutions

This series of 1 day workshops will begin in two locations in the USA, providing a unique opportunity to discover the in-situ solutions developed by the four partners of the alliance. If mechanical, electrical and optical characterizations methods are of interest then please join us! A wide variety of applications will be presented to cover different aspect of your research projects.

Locations

23 April 2024 | Sunnyvale, CA | 9am – 3pm| Covalent Metrology, *Sign up here*

25 April 2024 | Boston, MA | 9am – 3pm| Massachusetts Institute of Tech. (MIT) *Sign up here*

Sunnyvale Program (23 April 2024)

09:00 - 09.45 Registration and Coffee

09:45 - 10:00 Introduction of Covalent Metrology and the In-situ Microscopy Alliance (IMA)

10:00 - 10:30 Recent innovation in small-scale in-situ mechanical properties testing, Dr. Nicholas Randall, Alemnis

10:30 - 11:00 Investigating Fracture Toughness of Architected Materials at the Micro-scale, Abdulaziz Alrashed, University of Washington

11:00 - 11:15 Break and networking

11:15 - 11:45 Latest updates in electro-optical characterizations and failure analysis, Mr. Karl Boche, Imina Technologies

11:45 - 12:15 Metal layers short localization with EBAC and FIB circuit modifications, Mr. Karl Boche

12:15 - 13:30 Lunch

13:30 - 14:00 AFM-in-SEM - step forward for in-situ correlative microscopy, technology and applications, Mr. Jan Neuman NenoVision

14:00 - 14:30 Benefits of AFM-in-SEM for applications in material science and battery research, Mr. Jan Neuman, NenoVision

14:30 - 15:30 Lab tour, open discussion, end of the seminar

Abstracts:

Recent Innovation in Small-Scale In-Situ Mechanical Properties Testing

Nicholas Randall

Alemnis, Schorenstrasse 39, CH-3645 Gwatt (Thun), Switzerland
*nicholas.randall@alemnis.ch

In situ SEM micro- and nanomechanical testing is an indispensable technique for materials design as well as for fundamental mechanics research. Many new protocols and testing geometries beyond traditional nanoindentation now enable the study of microstructure–property relationships, material intrinsic behaviour including orientation-dependence and plasticity, fracture dynamics, or the performance of novel micro-3D-printed metamaterials, to name but a few.

Thanks to its versatility, in situ SEM-based micromechanics is contributing to numerous scientific domains, including thin films and coatings, metallurgy, glasses and ceramics, semiconductors, biomechanics, or architectured materials. Performing micromechanical tests in situ in a SEM offers two important advantages: (1) unmatched control, stability, and positioning accuracy, and (2) the possibility to perform unique correlative experiments based on, for example, the combination of mechanical data with direct imaging or EBSD measurements.

An increasingly important branch of micromechanical testing can be found in the simulation of real-world, extreme operation conditions, such as high temperatures in engines, cryogenic temperatures in hydrogen storage, dynamic loading under shock or impact, high frequency cyclic fatigue, or a combination thereof. Progress in the understanding of material behaviour at such conditions is clearly linked to the availability of laboratory equipment that can perform reliable tests under such conditions.

New correlative methods of in-situ micromechanical testing will be presented, including the combination of the Alemnis ASA with the Nenovision AFM and Imina electrical nanoprobing systems.

Investigating Fracture Toughness of Architected Materials at the Micro-scale

Abdulaziz Alrashed

University of Washington, Mechanical Engineering Department
Stevens Way, Seattle, WA 98195
* abal6078@uw.edu

Materials derive their properties mainly from their microstructure, architecture, and length scale. Natural materials demonstrate remarkable mechanical properties due to the presence of multi-material hierarchical architectures that takes place at different length scales, and with the rapid progress in additive manufacturing techniques, specifically Two-photon Lithography, it is possible to mimic the complex architectures found in nature and fabricate structures with nano-meter scale resolution.

Our work focuses on understanding the mechanisms that can enhance a material's fracture toughness, derived from manipulating their architecture and/or from tapping into micro-scale induced size effect properties. We perform in-situ microscale fracture tests on single edge notch bend (μSENB) specimens to characterize toughness and observe the crack path behavior. Our goal is to create metamaterials that possess high strength-to-weight ratios and exceptional fracture toughness properties.

Latest updates in electro-optical characterizations and failure analysis

Karl Boche

Imina Technologies, Route de Montheron 8b, CH-1053 Cugy (Vaud), Switzerland
*boche@imina.ch

Increasingly complex semiconductor device developments, such as three-dimensional device architecture, pose serious challenges in failure analysis. To ensure efficient and safe device operation, engineers need to localize and understand electrical failure in elements with complex shapes and overlapping structures and fields. It becomes increasingly hard to interpret images and to correctly distinguish between Electron Beam Induced Current (EBIC) and Electron Beam Absorbed Current (EBAC), or between Resistive Contrast Imaging (RCI) and Electron Beam Induced Resistance Change (EBIRCH). This trend poses two somewhat opposite requirements on the failure analysis workflow: on one hand, more complex data has to be collected, but at the same time, there is a need for more intuitive data visualization and interpretation.

In this talk, we will show several examples that illustrate how to combine multi-channel imaging and color coding to bring this much-needed improvement.

AFM-in-SEM - step forward for in-situ correlative microscopy, technology and applications

Jan Neuman

NenoVision, Purkynova 649/127, 612 00 Brno, Czech Republic
* jan.neuman@nenovision.com

Correlative in-situ microscopy, which combines the benefits of different imaging systems, has become an essential tool helping us to understand the complexity of the sample properties. For these reasons, correlative microscopy is one of the hot topics of nowadays research. When we imagine a combination of two complementary techniques, atomic force microscopy (AFM) and scanning electron microscopy (SEM), this setup has several advantages, such as the complexity of the measurement, in in-situ conditions, and with precise localization to the area of interest.

To be able to combine these techniques, NenoVision company has developed a unique Atomic Force Microscope (AFM), LiteScope™, for easy „plug & play“ integration into the SEMs. The connection of AFM and SEM enables the merging of the strengths of both techniques, resulting in effective workflow and possibilities of complex sample analysis that was difficult or readily impossible by conventional, separate AFM and SEM instrumentation.

During the presentation, we will select and demonstrate the performance and capabilities of the AFM-in-SEM technique on several examples chosen from a broad range of applications such as batteries, semiconductors, and material science. We will show in-situ correlative characterization of different material properties analyzed by the AFM, such as high-resolution topography, mechanical, electrical, and magnetic properties, and correlated with SEM images.

Benefits of AFM-in-SEM for applications in semiconductor failure analysis and battery research

Jan Neuman

NenoVision, Purkynova 649/127, 612 00 Brno, Czech Republic
* jan.neuman@nenovision.com

During the talk, we will demonstrate the benefits of AFM-in-SEM characterization capabilities on various examples from the semiconductor failure analysis and characterization of battery materials and components.

The AFM-in-SEM approach, combining Atomic Force Microscopy (AFM)-based techniques with Scanning Electron Microscopy (SEM)-based or Focused Ion Beam (FIB)/SEM-based techniques, provides means to integrated correlative approach for studying semiconductor materials and devices. This solution allows for non-destructive mapping of diverse electrical properties of trenches, measuring gate dimensions, or localizing defects, which could help to understand the device processes. This approach provides the advantages of combining the benefits of capabilities of site-specific sample preparation by FIB, and ultra high resolution imaging by SEM and AFM techniques. This integration helps reveal the structures below the sample surface and measure various properties at the exact location under in-situ conditions. Additionally, it provides quantitative 3D information while avoiding sample or environmental changes such as differential pressure or sample contamination.

Highly air-sensitive samples from the battery industry are difficult to work with, especially when the analysis requires multiple instruments. Such is the case with the cathode active material (NCM) dispersed within the solid electrolyte SE. While Atomic Force Microscopy (AFM) can map the conductivity of the grains in electrolytes, it is not feasible to perform such measurement on a sample degraded by exposure to air and humidity. We will demonstrate how in-situ analysis can reveal crucial information about cathode materials, their degradation, and characteristics of failures significantly influencing the overall battery performance. Additionally, we will present the overall analytics workflow, enabling the analysis of battery materials and components at the nano/microscale level.