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Report from the NIST-MAS-AMAS Roadmap Workshop on Variable Pressure Scanning Electron Microscopy/Environmental Scanning Electron Microscopy

Scott A. Wight*, Dale E. Newbury* and Brendan Griffin**

*National Institute of Standards and Technology, Gaithersburg, MD 20899-8370
** University of Western Australia, Perth, Australia

The National Institute of Standards and Technology (NIST) co-organized and hosted a workshop on Variable Pressure Scanning Electron Microscopy (VPSEM) /Environmental Scanning Electron Microscopy (ESEM) with the Microbeam Analysis Society (MAS) and the Australian Microbeam Analysis Society (AMAS), November 2 to 4, 2005 at the NIST Gaithersburg, Maryland campus. This was the fourth in a series of annual MAS topical conferences jointly sponsored with and held at NIST. The NIST-MAS-AMAS VPSEM-ESEM Roadmap Workshop drew 60 participants from 6 countries and represents the third in a continuing series (1999 and 2001 were hosted by AMAS in Australia) of VPSEM-ESEM workshops. These workshops have brought together leading experts on VPSEM-ESEM to discuss the current state of achievement and understanding and to identify those areas where information is lacking and critical experiments and/or theoretical studies are required to advance the field.

The 2005 VPSEM-ESEM Roadmap Workshop sessions covered six major topics, each of which was highlighted by one or more invited speakers (the speaker only is listed on multiple author presentations):

1. Electron and ion interactions in the gas environment (including detectors)

Presentation	Speaker
Ion Dynamics in the ESEM	Matthew Phillips
Electron-Gas scattering processes in low vacuum	Brad Thiel
SE Detector Design Criteria for different low vacuum applications	Ralph Knowles
Gas-surface interactions in ESEM	Milos Toth

2. Contrast mechanisms in VPSEM-ESEM

Presentation	Speaker
Introduction - what do we mean by contrast?	David Joy
Contrast in Charge Collection Microscopy, how, why, what?	Brendan Griffin
CCI Contrast from soft tissue sample	Peda Clode
Microscopy and Microanalysis in liquids	David Joy
Atomic level imaging in liquids	Niels de Jonge

3. VP Metrology

Presentation	Speaker
Special Considerations for CD-Metrology in Low Vacuum	Brad Thiel
The effects of operating parameters on environmental SEM Metrology	David Joy
Optimizing signal to noise ratio in gas cascade amplification	Vasiliki Tileli
ESEM-based Reference Metrology System	Andras Vladar
ESEM charge control and contamination reduction for high resolution critical dimension microscopy	Milos Toth

4. Dynamic Experiments

Presentation	Speaker
Dynamic Experiments in Heating and Cooling in the ESEM	Ken Severin
ESEM experiments in a gas flow heating stage	Charlotte Appel

5. VPSEM-ESEM FIB

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FIB/ESEM DualBeam Instrumentation and Applications	Lucille Giannuzzi
An ESEM and FIB Workstation in one Instrument – Applications	John Mansfield
FIB SEM of Insulating Materials: Issues, Solutions, Questions	Debbie Stokes
6. Microanalysis in VPSEM-ESEM	
Quantitative Analysis Procedures	Eric Doehne
X-ray Optics for Reduction of Gas Scattering Contribution	Walter Gibson
Accuracy and Precision of Quantitative X-ray Analysis using ESEM	Robert Carlton
Monte Carlo Software for Estimating Gas Scatter Contributions	Nicholas Ritchie

The seventh session comprised the Roadmap discussions, covering a wide range of topics organized around a series of provocative statements with designated pro and con responders:

1. We should still separate VPSEM (<270 Pa) from ESEM (>2 Torr)
2. True high resolution SEM metrology is only possible with VP-ESEM
3. 90% of SEM will be VP-ESEM
4. Secondary electron imaging does not occur in VP-ESEM – it is all tertiary
5. CCI provide images of sample detail that is unique to the VP-ESEM
6. Charge implantation/accumulation in insulators dominate imaging and analysis processes in VP-ESEM
7. Ion capture by widgets is useful and should be very near the detector
8. Self-cleaning processes in VP-ESEM are critical to semiconductor applications
9. Luminescence-based detectors are more efficient and will become the detector of choice in VP-ESEM
10. S/N is be the prime measure of VP-ESEM detector performance
11. Field emission sources restrict imaging gas options by excluding noble gases
12. X-ray microanalysis in the VP-ESEM must be considered macroanalysis
13. Reliable, routine quantitative microanalysis of insulators is impossible in VP-ESEM
14. Quantomix capsules are a better approach for wet imaging & microanalysis

An attempt has been made to capture as much as practically possible of the information presented at the workshop and make it available to a worldwide audience. Session speakers, roadmap responders, and participants were therefore asked to provide text and/or visual records of their presentations and written comments. The record is available at
http://www.microbeamanalysis.org/mas/workshop/CD.htm
While such a Web-based resource can never replace the experience of actually attending the Workshop, the material may still prove useful to the VPSEM-ESEM community as a source of current thinking and information on current projects, made available substantially prior to the appearance of the finished material in the appropriate journals.

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