**Scanning Electron Microscopy and X-ray Microanalysis**

June 5-9, 2023

Course Outline

(Lectures are in boldface, lab titles in normal font)

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Options for special interests on Thursday and Friday

As described in our brochure, we offer optional lectures and labs about specific areas of interest. Our three optional sequences are: X-ray Analysis (X), Imaging Techniques (I), and Applications (A). Our sequence on applications addresses topics such as forensic science, polymers, microelectronics, food materials, and failure analysis. Lecture notes for all options are on the flash drive you were given at registration. The chart below will help you to decide which option is best for you. Yes, you can mix and match, but you should note that some sessions in each option build upon previous sessions. **Please choose one lab or lecture per time slot.**

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|  | **X-ray (X)** | **Imaging (I)** | **Applications (A)** |
| Thurs. 1:15 | 🞎 X-ray Microanalysis in VPSEM | 🞎 Forensic Spec. Prep | 🞎 Forensic Spec. Prep  🞎 Lab: Mechanical Testing |
| Thurs. 2:45 | 🞎 Basic SEM Maintenance  🞎 SEM Specimen Preparation | 🞎 Basic SEM Maintenance  🞎 SEM Specimen Preparation | 🞎 Basic SEM Maintenance  🞎 SEM Specimen Preparation  🞎 Lab: Mechanical Testing |
| Thurs. 4:00 | 🞎 Forensic Imaging/EDS | 🞎 Lab: VP SEM  🞎 Forensic Imaging/EDS  🞎 SEM of Electronic Materials | 🞎 Lab: VP SEM  🞎 Forensic Imaging/EDS  🞎 SEM of Electronic Materials |
| Thurs. 7:00 | 🞎 X-ray Analysis: Special Situations  🞎 EBSD | 🞎 Lab: SEM of Electronic Materials  🞎 EBSD | 🞎 Lab: SEM of Electronic Materials  🞎 EBSD |
| Thurs. 8:15 | 🞎 EDS Spectrum Simulation | 🞎 Lab: Low-Voltage SEM  🞎 SEM of Polymers | 🞎 Lab: Low-Voltage SEM  🞎 SEM of Polymers |
| Fri. 8:30 | 🞎 Reporting X-ray Results  🞎 Lab: EBSD | 🞎 Lab: EBSD  🞎 Lab: Forensics | 🞎 Lab: Forensics  🞎 Lab: EBSD |
| Fri. 9:45 | 🞎 Course Summary | 🞎 SEM of Fracture Surfaces  🞎 Course Summary | 🞎 SEM of Fracture Surfaces  🞎 Course Summary |
| Fri. 11:00 | 🞎 Course Summary  🞎 Basic SEM Maintenance | 🞎 Course Summary  🞎 Basic SEM Maintenance | 🞎 Course Summary  🞎 Basic SEM Maintenance |
| Fri. 1:15 | 🞎 Failure Analysis  🞎 Lab: EBSD | 🞎 Failure Analysis  🞎 Lab: EBSD | 🞎 Failure Analysis  🞎 Lab: EBSD |

\* In addition, all students have the opportunity over these two days to work on an SEM in pairs on samples of their choice.

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|  | **MONDAY, JUNE 5** |  |  |
| **Morning** |  |  |  |
| 8:30-8:45 | Welcome and Announcements | 303 | *Kiely (Chris)* |
| 8:45-9:15 | The SEM and Electron ProbeMicroanalyzer: An Introduction | 303 | *J.H. Scott* |
| 9:15-9:30 | Course Roadmap | 303 | *J.H. Scott* |
| 9:30-10:30 | SEM Imaging Modes | 303 | *Watanabe* |
| 10:30-10:50 | Break |  |  |
| 10:50-12:00 | Electron Sources, Electron Lenses andProbe Formation | 303 | Kiely (Chris) |
| **Afternoon** |  |  |  |
| Groups 1-6\* |  |  |  |
| 1:15-2:30 | Lab 1: SEM Imaging Modes Each group on a different SEM  (see blue sheets for SEM location) |  | Mansfield, Oshel, Kundu, K.Scott, Ritchie, Watanabe |
| 2:30-2:45 | Break |  |  |
| 2:45-4:00 | Lab 1: SEM Imaging Modes (continues) |  |  |
| Groups 7-12\* |  |  |  |
| 1:15-2:45 | Electron Beam-Specimen Interactions | 303 | Newbury |
| 2:45-3:00 | Break |  |  |
| 3:00-4:00 | Generation of X-ray Signals | 303 | J.H. Scott |
| All Groups |  |  |  |
| 4:15-5:15 | Elimination of Specimen Charging | 303 | Thiel |

\* Your lab group number is on your nametag and on the yellow sheet

in your notebook.

**NOTE:** Student samples will be collected this evening and

Tuesday evening (6:15-7:00) in Whitaker Lab lobby.

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|  | MONDAY, JUNE 5 (Continued) |  |  |
| **Evening** |  |  |  |
| 6:15-7:00Groups 1-6 | **Optional Informal Discussions on**  **Specimen Preparation** | 303  Lobby | *Oshel/*  *O’Brien* |
| 7:00-8:15 | Electron Beam-Specimen Interactions | 303 | Newbury |
| 8:15-8:30 | Break |  |  |
| 8:30-9:30 | Generation of X-ray Signals | 303 | J.H. Scott |
| Groups 7-12 |  |  |  |
| 7:00-8:15 | Lab 1: SEM Imaging Modes Each group on a different SEM  (see blue sheets for SEM location) |  | Mansfield, Oshel, Kundu, K.Scott, Ritchie, Watanabe |
| 8:15-8:30 | Break |  |  |
| 8:30-9:30 | Lab 2: SEM Imaging Modes (continues) |  | As above |

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|  | **TUESDAY, JUNE 6** |  |  |
| **Morning** |  |  |  |
| 8:30-10:00 | Image Formation | 303 | Newbury |
| 10:00-10:30 | Break |  |  |
|  | **NOTE**: Student Samples will be collected in  the lobby this evening (6:15-7:00 p.m.).  **NOTE**: Sign-up Sheets for use of equipment  will be in the lobby today. |  |  |

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| 10:30-12:00 | Image Contrast | 303 | Michael |
| **Afternoon** |  |  |  |
| *Groups 7-12* |  |  |  |
| 1:15-1:25 | Roadmap Update | 303 | J.H. Scott |
| 1:25-2:40 | X-ray Detectors (EDS) | 303 | J.H. Scott |
| 2:40-3:00 | Break |  |  |
| 3:00-4:00 | X-Ray Qualitative Analysis (EDS) | 303 | Thiel |
| *Groups 1-6* |  |  |  |
| 1:15-2:30 | Lab 2: Image Contrast and Quality *(see blue sheets for SEM location)* |  | Oshel, Ritchie, Kiely,  *Watanabe,*  *Kundu*  *Mansfield* |
| 2:30-2:45 | Break |  |  |
| 2:45-4:00 | Lab 3: Image Contrast and Quality (continues) |  | As above |
| *All Groups* |  |  |  |
| 4:15-5:15 | Types of Electron Detectors | 303 | Mansfield |
| **Evening** |  |  |  |
| 6:15-7:00 | **Optional Informal Discussions on** Specimen Preparation | 303  Lobby | Oshel/  *O’Brien* |
| *Groups 7-12*7:00-8:15 | **TUESDAY, JUNE 6 (Continued)** Lab 3: Image Contrast and Quality |  | Oshel, Ritchie, Kiely  *Watanabe,*  *Kundu*  Mansfield |
| 8:15-8:30 | Break |  |  |
| 8:30-9:30 | Lab 3: Image Contrast and Quality (continues) |  | As above |

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| **Evening** |  |  |  |
| Groups 1-6 |  |  |  |
| 7:00-7:10 | Roadmap Update | 303 | J.H. Scott |
| 7:10-8:25 | X-ray Detectors (EDS) | 303 | *J.H. Scott* |
| 8:25-8:45 8:45-9:45 | Break **X-ray Qualitative Analysis (EDS)** | 303 | Thiel |

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|  | **WEDNESDAY, JUNE 7** |  |  |
| Morning |  |  |  |
| 8:30-9:30 | Digital Imaging and Compositional Imaging | 303 | Watanabe |
| 9:30-10:00 | **How to use the Lehigh Web-based Software** |  | *Watanabe* |
| 10:00-10:15 | Break |  |  |
| 10:15-10:35 | **Roadmap Update** | 303 | J.H. Scott |
| 10:35-12:00 | Quantitative X-ray Analysis: The Basics | 303 | J.H. Scott |
| **Afternoon** |  |  |  |
| Groups 1-6 |  |  |  |
| 1:15-3:00 | Lab 3: EDS Detectors and X-ray Spectra*(see blue sheets for SEM location)* |  | Mansfield, Thiel  *Ritchie*  *Oshel*  *Watanabe*  J.H.Scott |
| Groups 7-12 |  |  |  |
| 1:15-3:00 | X-ray Microanalysis by Energy-Dispersive Spectrometry | 303 | Newbury |
| 3:00-3:15 | Break |  |  |
| Groups 1-6 |  |  |  |
| 3:15-5:00 | X-ray Microanalysis by Energy-Dispersive Spectrometry | 303 | Newbury |
| Groups 7-12 |  |  |  |
| 3:15-5:00 | Lab 3: EDS Detectors and X-ray Spectra*(see blue sheets for SEM location)* |  | Mansfield, Thiel  *Ritchie*  *Oshel*  *Watanabe*  *J.H.Scott* |
| 6:30 | Cocktail Hour – Faculty Lounge, University Center |  |  |
| 7:30 | Course Banquet – Faculty Dining Room, University Center |  |  |

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| **Key to options for lectures and labs on Thursday and Friday:**  **X** = X-ray Analysis **I** = Imaging Techniques **A** = Applications  *These lectures correspond to notes on the flash drive.* |

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|  | **THURSDAY, JUNE 8** |  |  |
| **Morning** |  |  |  |
| 8:30-9:30 | **High Resolution SEM** | 303 | *Michael* |
| 9:30-10:15 | **Stereomicroscopy** | 303 | *Kiely(Carol)* |
| 10:15-10:30 | Break |  |  |
| 10:30-11:15 | Low-Voltage SEM and Microanalysis | 303 | *Michael* |
| 11:15-12:00 | **Variable Pressure and Environmental SEM** | 303 | *Mansfield* |

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| Afternoon |  |  |  |
| 1:15-2:30 | **Choice**: |  |  |
|  | 1. **Forensic Specimen Preparation (A, I)**  2. **X-ray Microanalysis in the Variable**  **Pressure SEM and E-SEM (X)**  3.Lab: Small Scale Mechanical Testing in the SEM (A)  4. Lab: Paired sessions on SEM  with student samples (sign up) | 207  303  178 | *Platek*  *Newbury*  *Hintsala*  *Staff* |
| 2:30-2:45 | Break |  |  |
| 2:45-4:00 | **Choice:**  1. **Basic SEM Maintenance (X, I, A)**  2. **SEM Specimen Preparation (X, I, A)**  3. Lab: Small-Scale Mechanical Testing in the SEM (A)  4. Lab: Paired sessions on SEM  with student samples (sign up) | 207  303  178 | *O’Brien*  *Oshel*  *Hintsala*  *Staff* |
| 4:00-5:15 | **Choice**:  1. Lab: Variable Pressure SEM (X, I, A)  [Hitachi 4300]  [Tescan VEGA]  2. **Forensic Specimen Imaging and**  **Microanalysis (I, A)**  **THURSDAY, JUNE 8 (Continued)**  **3**. **Analysis of Electronic Materials and Devices (I, A)**  4. Lab: Paired sessions on SEM or EPMA  with student samples (sign up) | 172E  122  303  207 | *J. H. Scott*  *Mansfield*  *Platek*  *Thiel*  *Staff* |

**Evening**

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| 7:00-8:15 | **Choice:**  1. **X-ray Analysis in Special Situations: Thin Films, Rough Specimens, and Particles (X, A)**  2. **Electron Backscatter Diffraction**  **(EBSD) (X, I, A)**  3. Lab:Analysis of Electronic Materials and Devices (I, A)  [Hitachi 4300]  4. Lab: Paired sessions on SEM  with student samples (sign up) | 303  207  172E | *Newbury*  *Michael*  *Thiel*  *Staff* |
| 8:15-9:30 | **Choice:**  1. **SEM of Polymers**  2. **Practical Spectrum Simulation (DTSA-II) (X)**    3. Lab: Low-Voltage SEM (I, A)  [Zeiss LEO]  [Tescan VEGA]  4. Lab: Paired sessions on SEM  with student samples (sign up) | 207  257  178  122 | *Thiel*  *Ritchie*  *JH Scott*  *Mansfield*  Staff |

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|  | **FRIDAY, JUNE 9** |  |  |
| **Morning** |  |  |  | |
| 8:30-9:30 | **Choice**:  1. **The EDS Microanalysis Process:**  **Preparing the Analytical Report**  2. Lab: EBSD (X, I)  [Hitachi 4300/EDAX]  [Scios FIB/EDAX]  3. Lab: SEM/EDS in Forensic Science (A)  [Tescan VEGA]  4. Lab: Paired sessions on SEM or EPMA  with student samples (sign up) | 207  172E  172B  122 | *Newbury*  *Michael/Kundu*  *Michael/Kundu*  *Platek/Mershon*  *Staff* | |
| 9:30-9:45 | Break |  |  | |
| 9:45-10:45 | **Choice**:  1. **Course Summary: Strategies for**  **Practical Microscopy and Microanalysis**  2. **SEM Analysis of Fracture Surfaces (I, A)**  3. Lab: Paired sessions on SEM or EPMA  with student samples (sign up) | 303  207 | *J.H.Scott*  *Hertzberg*  *Staff* | |
| 10:45-11:00 | Break |  |  | |
| 11:00-12:00 | **Choice**:  1. **Course Summary: Strategies for**  **Practical Microscopy and Microanalysis**  2. **Basic SEM Maintenance**  3. Lab: Paired sessions on SEM or EPMA  with student samples (sign up) | 303  207 | *J.H.Scott*  O’Brien  Staff | |
| **Afternoon** |  |  |  | |
| 1:15-2:15 | **Choice:**  1. **Failure Analysis in the SEM (X, I, A)**  2. Lab: EBSD (X, I)  [Hitachi 4300/EDAX]  3. Lab: Paired sessions on SEM or EPMA  with student samples (sign up) | 303  172E | *Hertzberg*  *Michael/Kundu*  *Staff* | |