

Imaging of Materials

“Where the telescope ends, the microscope begins”

Spring 2013
Masdar Institute

Instructor: Amal Al Ghaferi
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Office Hours: Mon 10 -12 noon
Wed 10 -11 am
By appointment

Credits : 3 credit hours

Rationale:

Imaging of Materials is a fundamental elective course. It will provide the students with all the knowledge and practical experience to utilize the electron microscopes facilities at Masdar Institute. The course will enable the student to differentiate between different types of electron microscopes and electron microscopy techniques. At the end of the course the students will be able to utilize the electron microscopy facilities to his/ her project.

Course Objectives:

This course will study and investigate principles and applications of imaging techniques for materials characterization including transmission and scanning electron microscopy and scanning probe microscopy. Topics include: electron diffraction; image formation in transmission and scanning electron microscopy; diffraction and phase contrast; imaging of crystals and crystal imperfections; review of the most recent advances in electron microscopy for bio- and nanosciences; analysis of chemical composition and electronic structure at the atomic scale. Lectures are complemented by real-case studies and computer simulations.

Format and Procedures:

This course is structured to be conducted via lectures, practical demonstration sessions for different type of Electron Microscope that are available at Masdar Institute , group learning projects and students presentations.

Text Book and References :

1. C. J. Chen, *Introduction to scanning tunneling microscopy*. Oxford Science Publications: Oxford, 2008
2. Fultz, B.; Howe, J. M., *Transmission electron microscopy and diffractometry of materials*. Springer: Berlin, 2002.
3. Goldstein, J.; Newbury, D.; Joy, D.; Lyman, C.; Echlin, P.; Lifshin, E.; Sawyer, L.; Michael, J., *Scanning electron microscopy and X-ray microanalysis*. Springer: New York, 2003.

4. Graef, M. D., *Introduction to conventional electron microscopy*. Cambridge University Press: Cambridge, 2003.
5. Hirsch, P.; Howie, A.; Nicholson, R. B.; Pashley, D. W.; Whelan, M. J., *Electron microscopy of thin crystals*. Robert E. Krieger Publishing Co., Inc.: New York, 1977.
6. Reimer, L., *Scanning electron microscopy: physics of image formation and microanalysis*. Springer: Berlin, 1998.
7. Reimer, L., *Transmission electron microscopy: physics of image formation and microanalysis*. Springer: Berlin, 1997.
8. Spence, J. C. H., *High-resolution electron microscopy*. Oxford University Press: New York, 2003.

Grading Procedures:

Letter grades (A-F)

| Activities: | Percentage: |
|--------------------|-------------|
| Exam 1 | 20% |
| Exam 2 | 30% |
| Exam 3 | 20% |
| Term project/paper | 30% |

Term Paper:

Students will be divided into groups of 2-3; each group will develop a term paper that evaluates an electron microscopy problem according to research interests of the group members. The final deliverables are:

- 20-30 minute presentation, during which all group members must speak
- Final report, due 2 days before the final presentation

Tentative Course Schedule

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| Week 1 Jan. 20 2013 | General Course Info and Introduction |
| Week 1 Jan. 23 2013 | Electron Optics |
| Week 2 Jan 27 2013 | Scattering; Overview of basic crystallography |
| Week 2 Jan 30 th 2013 | Scanning Electron Microscopy: principles and detection modes |
| Week 3 Feb 3 rd 2013 | Scanning Electron Microscopy: detection modes and advanced techniques |
| Week 3 Feb 6 th 2013 | Electron diffraction: principles and practice, elastic scattering |
| Week 4 Feb 10 2013 | Electron diffraction: inelastic scattering |
| Week 4 Feb 13 2013 | Scanning electron Microscopy: case studies and demo |
| Week 5 Feb 17 2013 | SEM at Masdar Institute |
| Week 5 Feb 20 2013 | Test 1 |
| Week 6 Feb 24 2013 | Imaging in TEM: overview and kinematical theory |
| Week 6 Feb 27 2013 | Imaging in TEM: dynamical theory and case studies |
| Week 7 Mar 3 rd 2013 | High resolution TEM |
| Week 7 Mar 6 th 2013 | Aberration-corrected scanning transmission electron microscopy |
| Week 8 Mar 10 2013 | Energy-dispersive x-ray spectroscopy |
| Week 8 March 13 2013 | Electron energy loss spectroscopy |
| Week 9 Mar 17 2013 | TEM at Masdar Institute |
| Week 9 Mar 20 2013 | TEM summary |
| Week 10 Mar 24 2013 | Test 2 |
| Week 10 Mar 27 2013 | Introduction to AFM |
| Week 11 March 31 st 2013 | Spring Break |

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| Week 11 April 3 rd 2013 | Spring Break |
| Week 12 April 7 th 2013 | Atomic Force Microscopy |
| Week 12 April 10 th 2013 | Cathodoluminescence |
| Week 13 April 14 th 2013 | Microscopy of biomaterials and polymers, tomography |
| Week 13 April 17 th 2013 | Microscopy of nanomaterials |
| Week 14 April 21 2013 | Scanning tunneling microscopy and near-field scanning optical microscopy |
| Week 14 April 24 2013 | X-ray imaging |
| Week 15 April 28 2013 | Term project presentations |
| Week 15 May 1 st 2013 | Term project presentations |
| Week 16 May 5 th 2013 | Summary |
| Week 16 May 8 th 2013 | Test 3 |