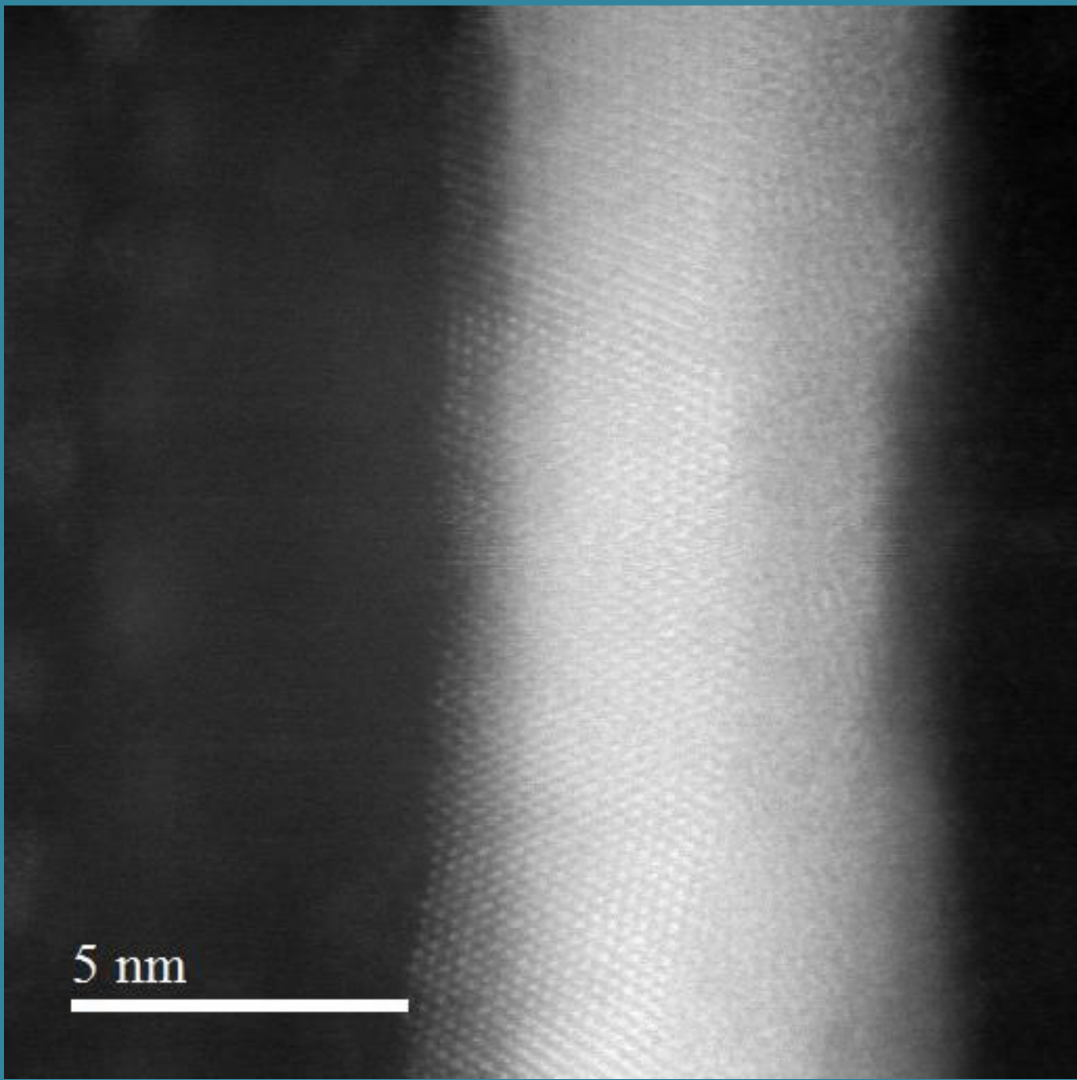
University of Glasgow | School of Physics & Astronomy



PHYS5041 Nano & Atomic Scale Imaging (NASI) 1

Course Information Guide 2023/2024

Course Details

PHYS5041 Nano & Atomic Scale Imaging (NASI) 1 is a level 5 Physics Honours course. It is a core course for students on the MSc: Advanced Functional Materials degree and those from the Centre for Doctoral Training: Photonic Integration for Advanced Data Storage (PIADS). It is an available elective course for students on any of the other MSc Physics degrees and the MSc Nanoscience & Nanotechnology (from School of Engineering). Following the course will require up to 100 hours of learning effort, participating in lectures, on-line learning activities and self-study of notes and textbook material. The course is delivered in Semester 1.

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Lecturers:

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Course Delivery

Lectures take place, Wednesdays 11:00 - 12:00 in Semester 1. These will consist of both synchronous and asynchronous learning activities based on the course notes, and may include text materials, quizzes and videos.

Lab sessions take place from 2pm on Wednesday afternoons when indicated in the course timetable. These involve image and spectroscopic data processing/analysis and sessions related to gaining better practical understanding of SEM, TEM and AFM.

All content is accessed via the Moodle page of the course.

Assessment

The course is assessed via submitted coursework related to two image/analytical lab exercises (26%), three instrument labs (39%) and a submitted final report task (35%).

Required Knowledge

Students are expected to have a knowledge of fundamental principles which underpin the imaging and analysis techniques. These include wave-particle duality, atomic electronic structure, special relativity, the effects of classical electromagnetic forces on charged particles, lensing / refraction and chemical bonding / material structure.

Recommended Texts:

- Scanning electron microscopy and X-ray microanalysis (Joseph I. Goldstein, Dale E. Newbury, Joseph R. Michael, Nicholas W.M. Ritchie, John Henry J. Scott, David C. Joy, 4th edition, 2018, Springer, New York). https://link-springer-com.ezproxy.lib.gla.ac.uk/book/10.1007%2F978-1-4939-6676-9
- Materials characterization: introduction to microscopic and spectroscopic methods – chapter on SEM (Y. Leng, 2013, Wiley, Weinheim) https://onlinelibrary-wiley-com.ezproxy.lib.gla.ac.uk/doi/book/10.1002/9783527670772
- Transmission electron microscopy: a textbook for materials science (David B. Williams; C. Barry Carter, 2nd edition, Springer, New York) https://link-springer-com.ezproxy.lib.gla.ac.uk/book/10.1007%2F978-0-387-76501-3
- Transmission electron microscopy: physics of image formation (Ludwig Reimer, Helmut Kohl, 5th edition, Springer, New York) https://link-springer-com.ezproxy.lib.gla.ac.uk/book/10.1007%2F978-0-387-40093-8

Intended Learning Outcomes

The aim of this course is to introduce the fundamentals of imaging materials at length-scales which ultimately determine their properties and function. By the end of this course students will be able to:

1) Give a detailed description and compare the nature of electron interactions with bulk and thin samples and explain how the emitted and scattered radiation is used for imaging and diffraction in both the SEM and the TEM
2) Describe the function of the key components of an SEM, explain the mechanisms of contrast formation and how they are used to perform conventional imaging
3) Describe the function of the key components of a TEM and explain how they are used in the complete column to perform conventional imaging and diffraction

4) Elucidate the mechanisms of contrast formation for TEM images, including diffraction and phase contrast and explain the role of aberrations and defocus in controlling the contrast transfer function
5) Critically evaluate the factors limiting spatial resolution in both SEM & TEM
6) Describe the main features of electron diffraction as applied in the TEM, and its uses in determining the orientation, lattice parameters and symmetry of crystals
7) Apply knowledge of electron specimen interactions to describe the fundamentals of chemical spectroscopy in electron microscopy. Compare the types of information available from chemical signals in the SEM & TEM.
8) Describe the function of the key components of a scanning probe microscope and explain how they are used to perform imaging of films and surfaces

Course Outline

Details of the course content are listed below.

Principles of Imaging

- Length scales
- Fixed & scanned modes of imaging
- Linear Imaging Theory

Scanning Electron Microscopy

- Components of the SEM
- Electron-specimen interactions
- Imaging modes

Transmission Electron Microscopy

- Components of the TEM
- Electron-specimen interactions
- Imaging modes
- Phase contrast and the contrast transfer function
- Diffraction and crystallographic structure
- Chemical Spectroscopy

Scanning Probe Microscopies

- Atomic Force Microscopy
- AFM imaging modes
- Scanning Tunnelling Microscopy