Syllabus for MSE 6130: Surface Analysis

Instructor: Prof. Faisal Alamgir

Room: Clough 262

Office hours: Virtual, Fridays 2:00-4:00 pm (tentative)

Textbook: only as suggested references –

- Modern Techniques of Surface Science, D.P. Woodruff and T.A. Delchar, Cambridge press
- Elements of X-ray Diffraction. B.D. Cullity and S.R. Stock, Prentice Hall
- NEXAFS Spectroscopy, J. Stöhr, Springer

Topics:

1. Fundamentals
    a. Wave properties of particles and light
    b. The origins of atomic quantum numbers and their physical meaning
    c. Relation between the electronic structure and spectroscopy
        i. Spin-orbit coupling and its relevance to spectroscopy
        ii. Multiplicities of spin-orbit split states
    d. Inelastic scattering of radiation through electronic polarization; interactions of induced dipole with radiation
    e. Absorption coefficients, attenuation lengths and their energy dependence
    f. Energy dependence of:
        i. photon attenuation lengths and
        ii. electron mean-free path
    g. The “universal curve” and its relevant features
2. Electron transitions and core-hole processes
    a. Transitions and transition probabilities
    b. The uncertainty principle, the core-hole lifetime and fundamental limits to the energy resolution in spectroscopy
    c. Electronic excitation and relaxation processes
    d. Four sister core-hole methods and their comparisons: (U/X)PS, XES, AES and XAS
    e. Exercises with spectral fitting
3. Diffraction fundamentals
    a. Elastic scattering of waves and the use of radiation to measure the coherence in structure
    b. Laue and Psi modes of diffraction measurement
    c. Structural contributions to position, the intensity and the width of measured peaks in reciprocal space.
    d. Surface diffraction
    e. Low Energy Electron Diffraction (LEED)
4. Vibrational spectroscopy methods
    a. Infrared spectroscopy
    b. Raman spectroscopy

Exercise with real research problems

Students will compose and present research proposals aimed at procuring highly-competitive facility-time at large research institutions (such as national labs). The students will first identify their main research questions they are interested in solving with the help of the facility. For these questions, the students will be highly encouraged to use issues emanating from their graduate research project. They will then be asked to map the research questions they have to the suite of characterization tools available at the facility. The exercise will culminate in an oral presentation and a written proposal, both of which will be peer-reviewed by classmates.

Exercise with recording a "podcast episode"

Students will script conversations around topics inherent to the course. They will then be shown how to produce a podcast episode. Students will record these episodes for potential future podcast serial on topics inherent and adjacent to materials characterization and materials research in general.

Grading

Two in-class exams (25% each), class exercise (20%), final exam (30%)