

Electron Microscopy for Materials Characterization

Sep 2 – Oct 2, 2024

KZ7016 7.5hp <https://sisu.it.su.se/search/info/KZ7016/en>

The course will start on September 2 (Monday) at 9:15. Lectures, problem solutions and practical training sessions are conducted 9:15-12:00 and 13:00-16:00 according to the detailed schedule below. Demonstrations, problem solutions and practical training sessions are the *compulsory parts* of the course. Lectures and exercises will be given in C513. The students will be divided into groups for the practical sessions.

Teachers:

Kjell Jansson (KJ) kjell.jansson@mmk.su.se
Xiaodong Zou (XZ) xzou@mmk.su.se
Cheuk Wai Tai (CWT) cheuk-wai.tai@mmk.su.se

Teaching assistants:

Sofia Butonova (SB) sofiia.butonova@mmk.su.se
Evgeniia Ikonnikova (EI) evgeniia.ikonnikova@mmk.su.se

Course Responsible:

Xiaodong Zou xzou@mmk.su.se

Literature:

RE: *Physical Principles of Electron Microscopy: An introduction to TEM, SEM and AEM*, R.F. Egerton, Springer

WC: *Transmission Electron Microscopy: A Textbook for Materials Science*, D.B. Williams and C.B. Carter, 2nd edition, 2009, Springer. <https://libris.kb.se/bib/11775751>

ZHO: *Electron Crystallography - Electron microscopy and electron diffraction*, X. Zou, S. Hovmöller, P. Oleynikov, Oxford University Press. <https://libris.kb.se/bib/12544168>

CW: *Transmission Electron Microscopy*, C.B. Carter, D.B. Williams, eds., Cham, 2016, Springer. <https://libris.kb.se/bib/19667958>

* Additional materials handed out at the lectures and practical sessions.

The actual date of lab and exercise depends on the number of participants and will be finalized at the beginning of the course.

| Week | Date | Teacher | | Lecture (9:15 – 12:00) | Literature | Lab (13:00 -16:00) # |
|------|--------------|---------|-----|---|------------|---|
| 36 | 2/9 (Mon) | L1 | CWT | General introduction to electron microscopy as tools for materials characterization | RE: 5 | |
| | | | KJ | Introduction to scanning electron microscopy (SEM) | | |
| | 3/9 (Tue) | L2 | KJ | Introduction to Energy Dispersive Spectroscopy (EDS) and Wave Dispersive Spectroscopy (WDS) | RE: 6 | |
| | 5/9 (Wed) | L3 | KJ | Applications of analytical SEM techniques for materials characterization | * | |
| | 6/9 (Thurs) | | | | | SEM lab (Group A) - EI EDS demo lab (Group B) - SB |
| | 7/9 (Fri) | | | | | SEM lab (Group B) - EI EDS demo lab (Group A) - SB |
| 37 | 9/9 (Mon) | L4 | CWT | Introduction to transmission electron microscopy (TEM), electron-matter interactions | WC: 1-3 | |
| | 10/9 (Tue) | L5 | CWT | Instrumentation and Electro-optics, aberration correction | WC: 5-10 | Exercise 1 (Group A+B) – EI |
| | 11/9 (Wed) | L6 | CWT | TEM sample preparation (powder, FIB, ion milling, ultramicrotome, cryo-transfer) | WC: 10 | Introduction of TEM & sample preparation (Group A+B) - EI |
| | 12/9 (Thurs) | | | | | |

| | | | | | | |
|----|--------------|---------------------------------|-----|---|-------------------------|-------------------------------|
| | 13/9 (Fri) | L7 | XZ | Electron diffraction (ED) and phase analysis | WC: 11-13, 18 ZHO: 5 | TEM + ED lab (Group A) - SB |
| 38 | 16/9 (Mon) | L8 | XZ | Imaging: BF, DF and phase contrast | WC: 22-23 | TEM + ED lab (Group B) - SB |
| | 17/9 (Tue) | L9 | XZ | Contrast transfer function (CTF) and high-resolution transmission electron microscopy (HRTEM) | ZHO: 6 WC: 28, 30 | Exercise 2 (All) – SB & EI |
| | 18/9 (Wed) | | | | | HRTEM lab (Group A) - EI |
| | 19/9 (Thu) | | | | | HRTEM lab (Group B) - EI |
| | 20/9 (Fri) | L10 | CWT | Scanning transmission electron microscopy (STEM) techniques: BF, ADF, HAADF, iDPC | CW 11* | |
| 39 | 23/9 (Mon) | L11 | CWT | TEM/STEM Spectroscopy (EDS and Electron energy loss spectroscopy (EELS) | WC 4, 37-40* | |
| | 24/9 (Tue) | | | | | |
| | 25/9 (Wed) | | | | | STEM+EELS lab (Group A) - CWT |
| | 26/9 (Thurs) | | | | | STEM+EELS lab (Group B) - CWT |
| | 27/9 (Fri) | L12 | CWT | In situ TEM characterization techniques, Applications of analytical EM in sustainable materials chemistry | CW: 2 | |
| 40 | 30/9 (Mon) | L13 | ALL | Repetition: questions and answers | | |
| | 2/10 (Ons) | Examination (9:15-14:00) | | | | |