

## Electron Microscopy for Materials Characterization

Aug 28 – Sep 27, 2023

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

The course will start on August 28 (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](mailto:kjell.jansson@mmk.su.se)  
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### Teaching assistants:

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

### Course Responsible:

Xiaodong Zou [xzou@mmk.su.se](mailto: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, 2<sup>nd</sup> 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) #
35	28/8 (Mon)	L1	CWT KJ	General introduction to electron microscopy as tools for materials characterization Introduction to scanning electron microscopy (SEM)	RE: 5	
	29/8 (Tue)	L2	KJ	Introduction to Energy Dispersive Spectroscopy (EDS) and Wave Dispersive Spectroscopy (WDS)	RE: 6	
	30/8 (Wed)	L3	KJ	Applications of analytical SEM techniques for materials characterization	*	
	31/8 (Thurs)			SEM lab (Group A) - EI EDS demo lab (Group B) - SB		SEM lab (Group B) - EI EDS demo lab (Group A) - SB
	1/9 (Fri)			SEM lab (Group C) - EI EDS demo lab (Group D) - SB		SEM lab (Group D) - EI EDS demo lab (Group C) - SB
36	4/9 (Mon)	L4	CWT	Introduction to transmission electron microscopy (TEM), electron-matter interactions	WC: 1-3	
	5/9 (Tue)	L5	CWT	Instrumentation and Electro-optics, aberration correction	WC: 5-10	Introduction of TEM & sample preparation (Group A+B) – SB Exercise 1 (Group C+D) – EI
	6/9 (Wed)	L6	CWT	TEM sample preparation (powder, FIB, ion milling, ultramicrotome, cryo-transfer)	WC: 10	Introduction of TEM & sample preparation (Group C+D) - EI Exercise 1 (Group A+B) – SB

	7/9 (Thurs)	L7	XZ	Electron diffraction (ED) and phase analysis	WC: 11-13, 18 ZHO: 5	TEM + ED lab (Group A) - SB
	8/9 (Fri)			TEM + ED lab (Group C) - SB		TEM + ED lab (Group B) - SB
37	11/9 (Mon)	L8	XZ	Imaging: BF, DF and phase contrast	WC: 22-23	TEM + ED lab (Group D) - SB
	12/9 (Tue)	L9	XZ	Contrast transfer function (CTF) and high-resolution transmission electron microscopy (HRTEM)	ZHO: 6 WC: 28, 30	Exercise 2 (All) – SB & EI
	13/9 (Wed)			HRTEM lab (Group A) - EI		HRTEM lab (Group B) - EI
	14/9 (Thu)			HRTEM lab (Group C) - EI		HRTEM lab (Group D) - EI
	15/9 (Fri)	L10	CWT	Scanning transmission electron microscopy (STEM) techniques: BF, ADF, HAADF, iDPC	CW 11*	
38	18/9 (Mon)					
	19/9 (Tue)	L11	CWT	TEM/STEM Spectroscopy (EDS and Electron energy loss spectroscopy (EELS)	WC 4, 37-40*	
	20/9 (Wed)			STEM+EELS lab (Group A) - CWT		STEM+EELS lab (Group B) - CWT
	21/9 (Thurs)			STEM+EELS lab (Group C) - CWT		STEM+EELS lab (Group D) - CWT
	22/9 (Fri)	L12	CWT	In situ TEM characterization techniques, Applications of analytical EM in sustainable materials chemistry	CW: 2	
39	25/9 (Mon)	L13	ALL	Repetition: questions and answers		
	28/9 (Thurs)*	<b>Examination (9:15-14:00)</b>				

\*If there are students who need to take the next course on 28/9, the exam will be on Wednesday 27/9, 8:15-13:00 at K439-K433, KÖL.