Course description
Electron Microscopy Analysis of Fibre- and Polymer-based Materials
FCK3109, 7.5 credits, VT 2023

Course information

Welcome to the course of ***Electron Microscopy Analysis of Fibre- and Polymer-based Materials***! In this course you will be introduced to different electron microscopy techniques, sample preparation and recent state-of-the-art methodologies within the field of electron microscopy. The course consists of two parts: theoretical, including the lectures and seminars (3 credits) and hands-on parts (4.5 credits) where you will work with different electron microscopes that we have at FPT. Both parts are a prerequisite to independently run the electron microscopy facilities at FPT.

Canvas

All information related to the course will be available on Canvas. This includes lecture notes, instructions in the preparation of the proposal and schedules for the laboratory work. The Canvas page will continuously be updated throughout the course.

Intended learning outcomes

After completion of the course the doctoral student should have the knowledge and ability to

1) Explain the basic principles for electron microscopy (scanning electron and transmission electron microscopy) and demonstrate for the level of the course adequate acquired knowledge in the specialized topics of the course.
2) Suggest and explain, plan and carry out different types of electron microscopy related experiments.
3) Suggest, plan and perform sample preparation of a material so that it can be imaged with electron microscopy. Reflect on the selected sample preparation technique.
4) Present and orally motivate the selected electron microscopy instrumentation for a selected sample.

Electron Microscopy Analysis of Fibre- and Polymer-based Materials
FCK3109, 3 credits, VT 2023 KTH (Theoretical Part, SEM1)

Location: Treesearch Large Conference Room, Teknikringen 38
Zoom link for participants online: https://kth-se.zoom.us/j/62038923342?from=addon

W.	Time	Activity	Content	Teacher
7	**Monday 17/04/2023 "SEM, EDS and Sample Prep"**			
	10:15 –11:00	Lecture	Introduction to the Course. Introduction to Electron Microscopy	**AR**
	11:15 – 12:00			
	13:15 – 14:00		SEM basics	
	14:15 – 15:00		SEM-based microanalysis: EDS & WDS	
	15:15 – 16:00		SEM Sample Preparation	
	16:15 – 17:00		Cross-sectional sample preparation for SEM: mechanical polishing and BIB	
	Tuesday 18/04/2023 "TEM"			
	09:15 – 10:00	Lecture	TEM – the instrument and electron-to-matter interaction	**TW**
	10:15 – 11:00		Imaging and diffraction in TEM	
	11:15 – 12:00		STEM and other techniques in the TEM	
	13:15 – 14:00		TEM-based spectroscopy: EDS & EELS	
	14:15 – 15:00		TEM in Wood-related research	
	15:15 – 16:00		TEM Sample Preparation	**AR**
	Wednesday 19/04/2023 "Ultramicrotomy and Dual Beam"			
	09:15 – 10:00	Lecture	Ultramicrotomy	**AZ, AR**
	10:15 – 11:00			
	11:15 – 12:00			
	13:15 – 14:00			
	14:15 – 15:00		Dual Beam. Intro, TEM Sample preparation and 3D reconstruction	**AR**
	15:15 – 16:00			
	Thursday 20/04/2023 "Cryo and Environmental EM"			
	09:15 – 10:00	Lecture	TEM-based tomography and ETEM	**RW**
	10:15 – 11:00		Cryo-TEM	**CM**
	11:15 – 12:00			
	13:15 – 14:00		Cryo-SEM	**AR**
	14:15 – 15:00		Environmental SEM	
	15:15 – 15:30		EM Infrastructure overview	
	15:30 – 16:00		Summary of the course and instructions for the preparation of proposals	
9	**Thursday 04/05/2023 "Presentations"**			
	08:30 – 12:00	Oral exam	Oral presentations of proposals by students	**AR, AH**
	13:00 – 18:00			

AH: Anna Hanner (KTH), **AR:** Anastasia Riazanova (KTH), **RW**: Reine Wallenberg (LU), **CM:** Carsten Mim (KTH), **TW:** Tom Willhammar (SU), **AZ**: Agnieszka Ziolkowska (UCEM)

Deadline for the proposal submission: 26/04/2023 at 9:00

Lab work at KTH starts on 08/05/2023

Laboratory work (LAB1) (20 h):

The laboratory will be divided as follows:

Type of instrument/task	Demonstration	Practice
Lab safety	1h	
Sample preparation SEM	1h	0.5h
Table top SEM	1h	1.5h
Hitachi SEM	4h	1.5h
SEM-based EDS	3h	1h
STEM mode in SEM	2h	2h
Sample preparation TEM	1h	0.5h
Total	**13h**	**7h**

The schedule for the laboratory work will be coordinated with each participant individually after the course has started and will be published on Canvas after 26/04.
The laboratory work will start on 9/05.

Course contents

The course includes both *lectures*, *seminars* and *laboratory work*. The course covers the basic principles of different types of:

- Electron microscopy techniques, including: scanning electron microscopy (SEM), Tabletop SEM, transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM), cryo-SEM, cryo-TEM, focused ion beam (FIB), Dual Beam (SEM-FIB), energy dispersive X-ray spectroscopy (EDS).
- More advanced analysis techniques (in situ analysis) and 3D tomography.
- Different types of sample preparation techniques for optimal analysis of a specific sample.
- Hands-on experience of electron microscopy imaging.

Lectures (theoretical part of the course)

The course consists of 24 hours of lectures where the topics mentioned above will be covered. The lectures will be given physically at KTH and online via a Zoom to enable participation of the students from other universities.
The lectures will end with a full day of presentation by the students (hybrid: at KTH and via Zoom), where students present their individual proposals. Each student will be asked to write an application for utilizing a specific electron microscopy technique. The proposal will be presented orally (7 min) and feedback on the proposal will be provided by two other students in the course including the teachers (7 min questions and answers). A template of a proposal can be found on Canvas.

Laboratory work (practical part of the course)

The laboratory part (20 hours) of the course is a prerequisite to run the electron microscopy instruments at FPT. It is compulsory to attend all laboratory work sessions in order to pass this part of the course. The students are expected to come prepared before each session and in the end the students must be able to operate the instruments by themselves. Their performance will be evaluated by the lab responsible person. All information about the laboratory work, including schedule, will be provided during the course. If you fail on this part, you will have to redo the laboratory part the next time the course is given.

The max number of lab attendees is limited to 12 participants.

Responsible persons for the laboratory part:

Anastasia Riazanova, anaria@kth.se

Literature

Hand-outs from presentations, scientific articles and instruction manuals for running the electron microscopy instruments will be provided on Canvas, including:

1. FEI interactive booklet "An Introduction to Electron Microscopy", https://www.fei.com/documents/introduction-to-microscopy-document/#gsc.tab=0

Further reading:

1. P. J. Goodhew, J. Humphreys and R. Beanland "Electron Microscopy and Analysis", CRC Press, 30 Nov 2000, Technology & Engineering
2. Goldstein et al. "Scanning Electron Microscopy and X-ray Microanalysis" Springer 2018
3. David B. Williams, C. Barry Carter "Transmission Electron Microscopy. A Textbook for Materials Science" Springer 2009

Important dates:

Wednesday April 26th before 9:00 – deadline for the submission of the proposals.

Thursday May 4th (full day) – Oral examination. Presentation of the proposals.

Examination

SEM1 - Seminars, 3,0 hp, grades: P, F

LAB1 - Laboratory work, 4,5 hp, grades: P, F

To pass the theoretical part of the course (SEM1), the students are expected to attend at least in 80% of the lectures, pass the seminar part and be approved on the home-assignment (including submission, presentation and peer-review of the proposals).

To pass the practical part of the course (LAB1) the students are expected to participate in all lab activities and pass the performance evaluation part. The evaluation will be performed by the lab responsible.

Grading scale

Pass (P), Fail (F)

Contact information

Examiner: Anna Hanner, e-mail: svagan@kth.se

Course responsible: Anastasia Riazanova, e-mail: anaria@kth.se