RSEM
“Resurscentrum för Samordning av Elektronmikroskopi vid KTH”
”Resource Center for Coordination of Electron Microscopy at KTH”

Dr. Anastasia Riazanova
Director of RSEM
Research Infrastructure Coordinator at Treesearch
Wallenberg Wood Science Center (WWSC)
Department of Fibre and Polymer Technology (FPT)
Division of Fibre Processes & Division of Biocomposites

Goals of RSEM

• A new interim virtual centre at KTH
• To increase the knowledge and competence of the KTH researchers within the field of electron microscopy (EM)
• Make the EM infrastructure easily accessible to the KTH staff
• Provide support (application-based)
• Provide training
• Organize PhD courses within the EM field at KTH
• Provide information and guidelines on how to select correct EM techniques
• Create the network of dedicated EM specialist at KTH
• Create the network of dedicated EM users at KTH
• Increase the synergy between different research units at KTH
• Boost up the EM-related role of KTH nationally and internationally
RSEM Board

- Anastasia Riazanova, Director, CBH school
- Annika Borgenstam, Chairman, ITM school
- Nils Nordell, EECS school
- Philip Köck, CBH school
- Matthew Fielden, CBH school
- Peter Hedström, ITM school
- Oscar Tjernberg, SCI school

RSEM Specialists

- CBH school:
  - Anastasia Riazanova, Philip Köck, Carsten Mim, Pasi Purhonen, Caroline Ingeborg Jegerschöld, Gunilla Herting, Inna Soroka
- ITM school: Prasath Babu Revat Rajan, Peter Hedström, Wenli Long, Lyuba Belova
- SCI school: Jonas Weissenrieder, Fei Ye, Vladislav Korenivski

- Materials Science and Engineering
  - Steels, alloys, functional materials: Hultgren Laboratory
  - SEM, FIB-SEM, EDS, WDS, EBSD, Tomography
- Applied Physics
  - AlbaNova NanoLab: FIB-SEM
  - Kista Electrum: FIB-SEM, EDS, EBSD, TEM, EELS
  - Ultrafast EM: time-resolved TEM
- Fiber and Polymer Technology: SEM, TEM, EDS
- Structural Biotechnology: cryo TEM, Tomography
- Surface Chemistry and Corrosion Science: SEM-EDS
- Applied Physical Chemistry: SEM-EDS
Electron Microscopy Basics

**Resolution**

1 nm vs 0.05 nm

**Sample size & prep**

- Morphology & fine structure (SEM vs TEM)
- Chemical composition: EDS, WDS, EELS
- Crystallography: diffraction, EBSD
- In situ mechanical testing
- Temperature control: heating & cryo
- Environmental studies
- Ultrafast EM – time-resolved
- In situ modification and growth:
  - Dual Beam FIB-SEM: EBID, IBID, lithography
  - Tomography: FIB-SEM & TEM
- Advanced sample preparation:
  - e.g. TEM lamella lift-out in situ Dual Beam
  - Dynamic imaging: in situ observations

Examples of EM case studies
Superamphiphobic coatings

Nordenström et al
Scientific Reports 2018

LBL Microcapsules Paulraj et al Biomacromolecules 2017

Synthetic plant cell fabrication

Paulraj et al Nature Communications 2020
Dual Beam FIB-SEM

SEM + FIB = Dual Beam

©FEI Thermo Fisher Scientific

FIB-SEM Principles

©FEI Thermo Fisher Scientific
FIB-SEM 3D Reconstruction of Hydroxypropyl cellulose

© Cecilia Fager
ISBN 978-91-7905-301-7
Doktorsavhandlingar vid Chalmers Tekniska Högskola,
Ny serie nr 4768

"Quantitative 3D reconstruction of porous polymers using FIB-SEM tomography. Correlating materials structures to properties of coatings for controlled drug release”
Cryo-SEM of CNF - Polyacrylamide Aerogels

Figure 7. Cryo-SEM Images of C-17,5 with 5000x magnification (left) and 15,000x magnification (right).

Cryo TEM 3D Reconstruction of CNC

Figure 3. ET image of (a) pristine CNC and (b) CNC/G3 30/70 w/w. (c) Schematics of the proposed multivalent interactions between G3 peripheral dendritic units and the CNC surface glucose groups. (d) Schematics for irregular wrapping of G3 on CNC.
Fig. 1. Twisted morphology of cellulose nanocrystals. (a) CryoEM image of tCNCs. (b) and (c) Conventional TEM images of negatively stained tCNCs. (d) Images of tCNCs shadowed with a W/Ta alloy. In a–d, the arrowheads point toward the apparent twisted regions, and the dashed rectangles indicate the apparently untwisted tCNCs. (e) Schematized discontinuous twist morphology observed on CNCs under dry conditions. (f) MD-simulated cellulose nanocrystal showing a right-handed twist.
Fiber and Polymer Technology

Hitachi TEM HT7700 (120 kV)
Hitachi FEG-SEM S-4800
Deben Microtester 200N tensile stage
Hitachi Tabletop SEM TM-1000

- Cressington 208HR High Resolution Sputter Coater (Pt:Pd target)
- Cressington Carbon Coater 108Carbon/A

Anastasia Riazanova

Surface Chemistry and Corrosion Science

FEI XL-30 ESEM EDS

Gunilla Hertling

Applied Physical Chemistry

JEOL JSM-6490LV SEM, EDS

Inna Soroka
Cryo TEM Jeol 2100F
CBH Flemingsberg

ThermoFisher
Vitrobot for plunge freezing

Pasi Purhonen, Philip Köck, Carsten Mirm, Caroline Ingeborg Jegerschöld

Materials Science and Engineering Hultgren Laboratory

Hitachi S-3700
SEM, EDS, WDS

JEOL JSM-7800F
SEM, EDS, EBSD

FEI Nova 600
NanoLab
FIB-SEM
EDS, EBSD

Peter Hedström, Prasath Babu Revat
RSEM Collaboration Sites

CEM4MAT https://www.cem4mat.se/

CEM4MAT Centre of Electron Microscopy for Materials Sciences

Electron microscopy centre with excellent research infrastructure - open and accessible to all
Treesearch Research Infrastructure
EM expert nodes

- Center of Electron Microscopy for Materials Sciences (CEM4MAT)
- Resource Center for Coordination of Electron Microscopy (RSEM KTH)

- National Nodes for Sample Preparation and Microscopy (NanoSPAM)
- Atomic Resolution TEM Infrastructure Network of Sweden (ARTEMI)

Chalmers CMAL – Environmental SEM, Liquid TEM, Cryo FIB-SEM
Lund – Environmental TEM

KTH FPT – SEM (EDS), TEM of beam-sensitive samples
KTH CBH – Cryo TEM

MiUN MIL – advanced sample prep: cross-sectional studies
SLU – advanced sample prep: cross-sectional studies
SU MMK – UHR TEM: in situ diffraction & spectroscopy

https://treesearch.se/en/

"Roadmap" for EM methodology selection

- Formulate research question
- Select correct method

EM

TEM
- Advanced sample prep

SEM

Cryo
- Spectroscopy
- Diffraction
- Liquid
- Environmental
- Microanalysis
RSEM PhD Courses

- PhD course
- Open for everyone
- FPT-based (block-type)
- Invited teachers
- In a collaboration with Treesearch and CEM4MAT
- More courses under development: e.g. cryo-TEM, in situ spectroscopy, nano-to-microfabrication, materials science applications

Electron Microscopy Analysis of Fibre and Polymer Based Materials
FCK3109, 7.5 credits, VT 2021 KTH

Schedule (lectures, online). Literature: hand-outs

<table>
<thead>
<tr>
<th>W.</th>
<th>Time</th>
<th>Activity</th>
<th>Content</th>
<th>Teacher</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>09:15 – 10:00</td>
<td>Lecture</td>
<td>Introduction to Microscopy Imaging</td>
<td>AH</td>
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<tr>
<td></td>
<td>10:15 – 11:00</td>
<td></td>
<td>SEM basics</td>
<td>AR</td>
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<td></td>
<td>11:15 – 12:00</td>
<td></td>
<td>SEM-based microanalysis: EDS &amp; WDS</td>
<td>MH</td>
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<td>13:15 – 14:00</td>
<td></td>
<td>Cryo-SEM</td>
<td>NL, SP</td>
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<td>14:15 – 15:00</td>
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<td>15:15 – 16:00</td>
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Monday 01/03/2021 “SEM”

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<tr>
<td></td>
<td>09:15 – 10:00</td>
<td>Lecture</td>
<td>TEM – the instrument and electron-matter interaction</td>
<td>TW</td>
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<td></td>
<td>10:15 – 11:00</td>
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<td>Imaging using TEM and STEM, diffraction and other signals in the TEM</td>
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<td>11:15 – 12:00</td>
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<td>TEM in Wood-related research</td>
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<td>13:15 – 14:00</td>
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<td>TEM-based spectroscopy: EDS &amp; EELS</td>
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<td>14:15 – 15:00</td>
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<td>Cryo-TEM</td>
<td>CM</td>
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<td>15:15 – 16:00</td>
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Tuesday 02/03/2021 "TEM"
**Wednesday 03/03/2021 “Sample Preparation”**

<table>
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<tr>
<th>Time</th>
<th>Lecture</th>
<th>Presenter(s)</th>
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<tr>
<td>09:15 – 10:00</td>
<td>Ultrimicrotomy</td>
<td>AZ, SP</td>
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<td>10:15 – 11:00</td>
<td>Cross-sectional sample preparation for SEM: mechanical polishing and BIB</td>
<td>MH</td>
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<tr>
<td>11:15 – 12:00</td>
<td>Dual Beam (TIB-SEM), Intro</td>
<td>AR</td>
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<tr>
<td>13:15 – 14:00</td>
<td>Dual Beam, TEM Sample preparation</td>
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<td>14:15 – 15:00</td>
<td>Cryo-TEM tomography</td>
<td>LS</td>
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<td>15:15 – 16:00</td>
<td>TEM 3D reconstruction</td>
<td>TW</td>
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**Thursday 04/03/2021 “State-of-the-art EM”**

<table>
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<tr>
<th>Time</th>
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<tr>
<td>09:15 – 10:00</td>
<td>Environmental TEM vs cryo-TEM</td>
<td>RW</td>
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<td>10:15 – 11:00</td>
<td>SEM and FIB-SEM for liquid experiments and 3D imaging</td>
<td>EO</td>
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<tr>
<td>11:15 – 12:00</td>
<td>TEM: in situ advanced imaging and spectroscopy</td>
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<tr>
<td>13:15 – 14:00</td>
<td>Summary of the course and instructions for the preparation of proposals</td>
<td>AR, AH</td>
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<td>14:15 – 15:00</td>
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<td>15:15 – 16:00</td>
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**Monday 15/03/2021 “Presentations”**

<table>
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<tr>
<th>Time</th>
<th>Oral exam</th>
<th>AR, AH</th>
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<tr>
<td>09:00 – 12:00</td>
<td>Oral presentations of proposals by students</td>
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<td>13:00 – 17:00</td>
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AH: Anna Hanner (KTH), AR: Anastasia Rizanov (KTH), MH: Magnus Hummelgaard (MIUN), NL: Nikki Lee (UCEM), SP: Sofia Pettersson (Rowaco), TW: Tom Willhammar (SU), CM: Carsten Min (KTH), AZ: Agnieszka Zolikowska (UCEM), LS: Linda Sandblad (UCEM), RW: Reine Wallenberg (LU), EO: Eva Olsson (Chalmers)

THANK YOU VERY MUCH FOR YOUR ATTENTION!

FOR APPLICATIONS AND INQUIRIES, PLEASE CONTACT

anaria@kth.se