



Specialization project and Master thesis topics in the TEM Gemini Centre, 2026/27

TEM Gemini Centre

The TEM activity in Trondheim is centered around the TEM Gemini Centre, which consists of professors, engineers, postdocs and students at Dept. of Physics (IFY), NTNU and researchers in SINTEF Industry.

We have in total four TEM instruments and are part of the national infrastructure NORTEM. One of these is one of the most advanced available.

In 2026 we have at IFY 3.2 (assoc.) professors, 3 engineers, 5 SINTEF researchers, ~8 PhD students and ~10 MSc students with TEM as their main activity.

Our research extends through various fields of solid state physics and materials technology, from cooperation with industry on aluminum, solar cells, nano-materials and data analysis.

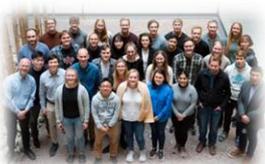
<http://www.ntnu.edu/gemini-centre/tem>

The transmission electron microscopy (TEM) Gemini Centre has four state-of-the-art microscopes. These TEMs include the most sophisticated technology available and give new possibilities for advanced materials characterization, novel experimental solid-state physics and nanotechnology down to the atomic scale. As a student in the TEM group, you will have a unique opportunity to use some of the world's most advanced scientific instrumentation yourself or work with data from them!

As a project or Master student in the TEM group you can take an active part in one of the exciting research projects which requires nanoscale material characterization. You work together with a PhD student, SINTEF researchers or one of our external collaborators to achieve a common goal. The work can have an applied character and be very practical, or theoretical to support experimental activities within the group. Also, a combination of practical and theoretical work is possible. In all projects TEM or input from TEM is used to understand the structure of a material down to the atomic level and relate this to macroscopic properties of the materials.

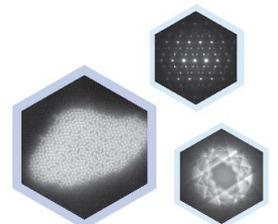
This document presents many suggestions for project/master projects—both experimental on functional, and structural materials, and pure analysis/coding exercises. Several of them, we have received from industrial partners. These projects are described in more detail in the next pages.

Earlier, several student projects have led to scientific publications [1-8]. Due to high demand on the research facilities and the intensive supervising we give, we can take in max 8 new students (5 hands-on experimental) in the group in the coming semester.



The TEM Gemini Centre is a strategic collaboration between NTNU and SINTEF. We work within the fields of solid state physics and materials science and study a broad range of materials down to the atomic level. Our lab hosts some of the most advanced transmission electron microscopes (TEM) in the world.

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- Choice of a project that fits your interests and background.
- Training in operating advanced and modern scientific equipment or/ and simulation and quantification software (theoretical/modelling).
- Weekly meetings with a supervisor during the project.
- Being part of a large and dynamic scientific consortium with group meetings once a week
- Possibilities in extending the project to a Master or a PhD.

We offer several projects connected to industry where we also offer summer jobs! We also offer work with Japanese Aluminium industry and a stay in Japan! Take a look at the different proposals. - Ask us about details!

All topics can be adjusted to 15, 30 or 60 ECTS. You are encouraged to contact one of us if you would like to hear more details on a specific project, other available projects, options in academia or industry after the master in TEM or possibilities to incorporate own research ideas related to TEM. For more information on the current activities within the group, group members, equipment, and recent publications, see the TEM Gemini Centre homepage:

<http://www.ntnu.edu/geminicentre/tem>.

Also, take a look at one of our videos:

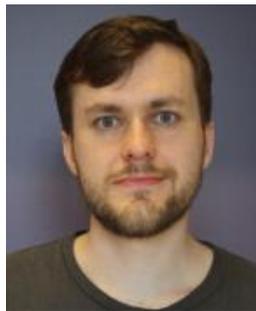
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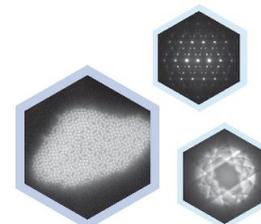
References: (master students in bold)

- [1] I.N. Ushakov, **M. Topstad** et al. Hybrid antiferroelectric-ferroelectric domain walls in noncollinear antipolar oxides, <https://arxiv.org/abs/2507.01622> Accepted for Nature Nanotechnology 2026
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- [5] F. de la Peña et al, Hyperspy 1.6 Zenodo. <https://zenodo.org/record/4294676#.YD0tkuhKg2w> and D. Johnstone et al, pyXem 0.13, Zenodo, <https://zenodo.org/record/4436723#.YD0p2ehKg2w> [Open-source software, >5 MSc listed as contributors]
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- [8] T. Bergh, **H. Fyhn**, L. Sandnes, J. Blindheim, Ø. Grong, R. Holmestad, F. Berto P.E. Vullum Multi-material Joining of an Aluminum Alloy to Copper, Steel, and Titanium by Hybrid Metal Extrusion & Bonding, Metall Mater Trans. A 54, 2689–2702, 2023. <https://doi.org/10.1007/s11661-023-07047-3>



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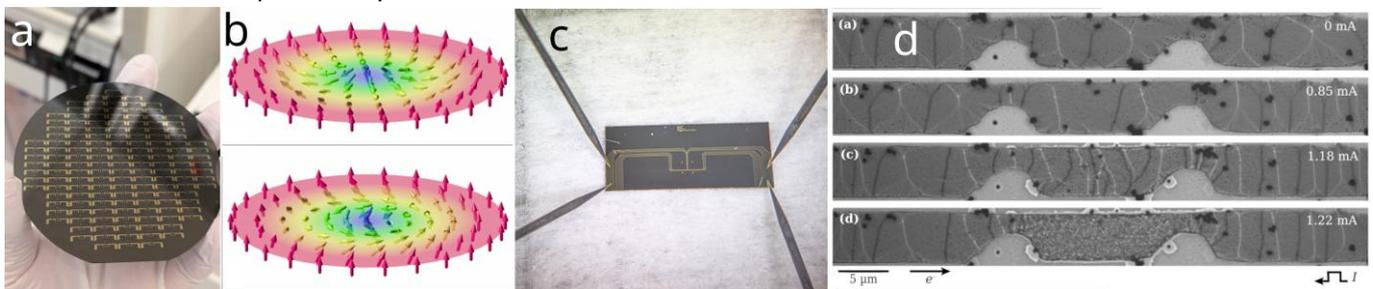




Fabricating *in-situ* TEM chips for characterization of magnetic skyrmions

Motivation

Skyrmions are nanoscale magnetic "whirlpools" which can be moved using small pulses of electric current and are candidates for future energy efficient devices. Due to their nanoscale size, and being purely a magnetic object, they are difficult to study. Transmission Electron Microscopy (TEM) is a technique where we can image nanoscale skyrmions, however making them move by applying an electric current inside the TEM is difficult. One way of doing this is by making specialized *in-situ* TEM chips, where the skyrmion thin film material is deposited onto a Silicon wafer, followed by deposition of contacts, a protective layer, then chemical etching. This leaves the skyrmion thin film on a very thin membrane with electrical contacts, suitable for TEM imaging of moving skyrmions. So far, we've made *in-situ* TEM chips with skyrmion thin film and electrical contracts.



a) Wafer of customized *in-situ* TEM chips. b) Spin structure of two different 2-D magnetic skyrmions, made by Karin Everschor-Sitte and Matthias Sitte, licensed under CC BY-SA 3.0. c) A single customized *in-situ* TEM chip, with measurement probes. d) *in-situ* TEM chip with the model system magnetic permalloy, before and after electrical biasing. Showing movement of the ferromagnetic domains and melting of the permalloy.

Your project

In the project you will be part of the ongoing project Nanoscale imaging of magnetic skyrmion dynamics in thin film devices (NIMSKY), working on improving the process for fabricating skyrmion racetracks on specialized TEM chips with electrical contacts. You will work closely with PhD student Sindre Vie Jørgensen and other researchers involved in the project. You will become an independent user of NTNU NanoLab. Techniques include lithography, wet and dry etching, and general characterization tools like electron microscopy. You will fabricate your own TEM chips with skyrmion racetracks and study them using characterization tools in the NTNU NanoLab. If the student is interested, there is a possibility of extending the project to include TEM work in the master's thesis semester. There will be room for tailoring the project towards the student's interest if she/he wishes to.

Requirements

Since the majority of this work will be carried out at NTNU NanoLab, the student should be interested in nanofabrication and process development. The student should have knowledge about nanofabrication and/or semiconductor technologies. Laboratory experience from courses similar to TFE4167 and/or TFY4330 are desirable, but not a prerequisite. The project can be adjusted to 15, 30, 45 or 60 ECTS.



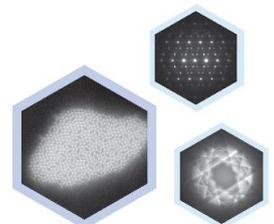
Contact persons

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- Sindre Vie Jørgensen, PhD candidate, Department of Physics, NTNU, sindre.v.jorgensen@ntnu.no



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In-situ magnetic imaging of ion-implanted magnetic nanostructures using FIB and TEM

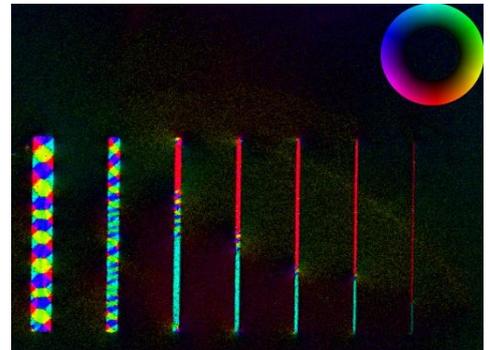
Motivation

With the increasing demand for more powerful and energy efficient computing devices, there is a need to move away from silicon based semiconductors. A potential concept is in-material computational devices, which can be made by creating nanomagnets. One way of making such nanomagnets, irradiating an FeV thin film using a Focused Ion Beam (FIB). During the ion irradiation, the non-magnetic FeV becomes ferromagnetic, allowing us to create different magnetic structures in the film (see the figure for an example of this in FeV). However, one critical issue is how the magnetic domains move inside the material, as a function of an external magnetic field or electrical current. The thin film consists of many small crystalline grains which can act as pinning sites for the magnetic domains, leading to the domains getting "stuck" at certain locations.

Your project

You will study the ferromagnetic domain structure of ion implanted FeV as a function of external magnetic field, utilizing Transmission Electron Microscopy (TEM). This will be combined with structural characterization using TEM diffraction and imaging, to figure out if and where the magnetic domain walls become pinned.

You will both learn and use the NTNU NanoLab FIB to create ion-implanted nanomagnets in the thin films. This will be followed by learning and using the NORTEM JEOL 2100 TEM, to characterize the materials. You will also learn how to do advanced data processing utilizing Python libraries such as HyperSpy and pyXem. The project can also include micromagnetic simulations using the mumax software on NTNU's Idun cluster. The project can be adjusted to 15, 30, 45 or 60 ECTS.



Ferromagnetic domains in ion-irradiated FeV, imaging using scanning transmission electron - differential phase contrast.

Requirements

The student should be interested in experimental work using the FIB and TEM, and programming using Python. The most relevant courses are Solid State Physics, Material Physics and Nanotools.



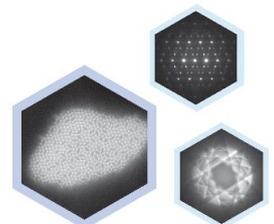
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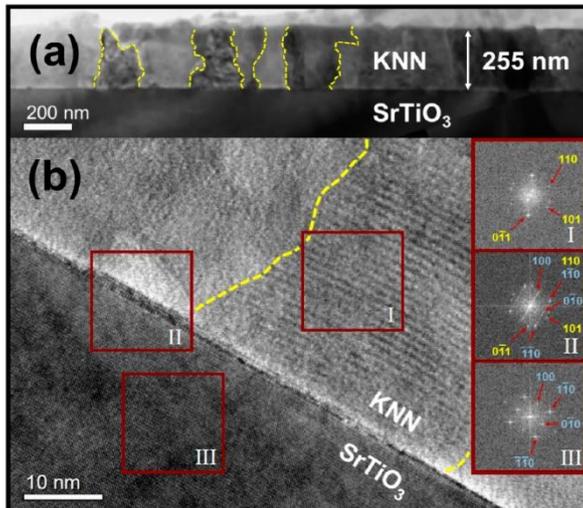
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TEM characterization of oxide thin films made by chemical methods

Motivation



TEM figure made by Andreas Toresen, MSc student in TEM group in 2018 [1].

Ferroc materials constitute a unique class of materials possessing either ferromagnetism, ferroelectricity or ferroelasticity. Two or more of these properties are found in so-called multiferroics. These materials have many applications in information and communication technology as well as in energy and in medical technology. Applications include sensors, transducers, actuators, etc. Lead-free materials such as $K_{0.5}Na_{0.5}NbO_3$ (KNN) and $Bi_{0.5}Na_{0.5}TiO_3$ (BNT), ferroelectric tungsten bronzes such as $Sr_{1-x}Ba_xNb_2O_6$ and multiferroic materials such as $BiFeO_3$ and $YMnO_3$ have been central to the research in the last decade[1]. At Department of Materials Science and Engineering, NTNU, they have many years of experience in developing these materials and the characterization of their structural and functional properties. TEM investigation allows determination of the detailed structure which can be related and compared to first principles calculations and functional properties.

Your project

The student will prepare samples (using Nanolab FIB or other routes) and examine them in the TEM, to support and complement other analyses being performed, and will work in close collaboration with others synthesizing the materials or studying the same materials with other techniques. There is a large activity at Gløshaugen on characterization of functional materials, and the student will be included in these activities, with participation in weekly lunch meetings etc.

Requirements

We seek students with background from physics, materials science or nanotechnology, interested in solid state physics/chemistry and/or nanoscience. If you are interested in experimental work, working independently and collaborating with the research groups synthesizing the materials/devices, please contact the advisors listed below.

Contact persons

Per Erik Vullum (per.erik.vullum@sintef.no)

This project is in collaboration with Mari-Ann Einarsrud from Department of Materials Science and Engineering.

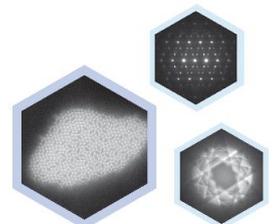


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Another natural way to capture CO₂

Motivation

The CO₂ levels in the atmosphere are too high. Reducing CO₂ is not enough to battle climate change and CO₂ capture and storage is also required. Atmospheric capture and subsurface storage is technical and economically challenging. Using biomass has limited capacity. A third way is enhanced rock weathering, which is a very large potential to permanently store large amounts of CO₂ in a relatively inexpensive way. The mineral central in that approach is olivine, nominally Mg₂SiO₄. Norway is one of the largest producers of olivine in northwest Europe. A detailed analysis of olivine-rich mantle rock known as dunite from Åheim can help to optimize CO₂ capture & permanent storage process. Transmission electron microscopy (TEM) is an essential tool to study structure, composition and transformations within and between minerals at the smallest scale.

What the student will do in the project

The student will learn hands-on to prepare samples and to operate a TEM for characterizing dunite, its microstructure, crystallographic and compositional properties. The project aims to link observations at different size scales (eg. optical microscopy/petrography – SEM – TEM) and different techniques (eg. microscopy, EDS, XRD). Consequently, sample and specimen preparation will be a part of the study. Your own TEM results have to be related to other techniques and carbon capture aim. You will relate large atmospheric and geological scale down to the atomic scale. In this project you will study the minerals that make up dunite. The project is a collaboration with the Geological Survey of Norway (NGU).

The project can be adjusted to 15, 30, 45 or 60 ECTS.

Required from the student

The perfect applicant has an interest in interdisciplinary experimental work, and is creative, inventive, self-reliant, independent, pro-active, and able to communicate cross-disciplinary with researchers from different disciplines.

Contact persons

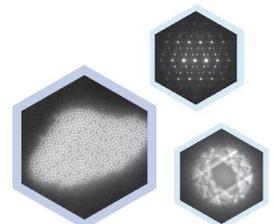
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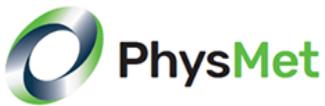
Maarten Broekmans (maarten.broekmans@ngu.no)



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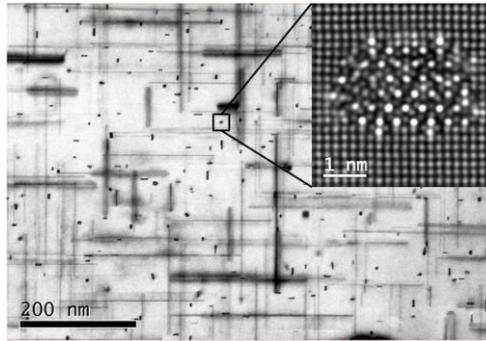
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TEM investigations of aluminium alloys

Motivation



Pure aluminium is a relatively soft metal, but with small additions of other elements it is possible to create alloys with significantly increased strength. Al-Mg-Si alloys are often

extruded into their final shapes and are subsequently heat treated to gain their high strength. The strength increase is achieved by small additions of Si and Mg which form nanosized particles called precipitates. These strengthening phases are so small that a transmission electron microscope (TEM) is required to study them. When documenting the hardness evolution during heat treatment, one usually finds a maximum hardness after a certain ageing time (peak-aged condition). The TEM Gemini Centre has for many years worked with industry on studies of aluminium alloys and precipitates. The work will contribute to the development and design of new aluminium alloys, mainly for the automotive industry. This year we have several interesting challenges: working with alloys from YKK (and go to Japan!), one from Hydro, and using machine learning on data from SINTEF. Some are given as own proposals, but please come and talk to us to get more details! The student will be invited to internal aluminium meetings as well as to project meetings in Trondheim or/and at industry sites.

Your project

The student(s) will here run different heat treatments and measure/get results from properties (such as hardness, strength, ductility, corrosion and conductivity). Afterwards the student will study the corresponding nanostructure (precipitates) in the TEM, supervised and in collaboration with PhD students and SINTEF researchers (who can help with more advanced microstructure characterization if needed). Different research problems are possible, depending on the interest of the student, and interest /projects with industry. Also, on data analysis of already acquired images – here you can participate in developing techniques and data analysis codes (see own suggestion).

Requirements

Background in materials physics, nanotechnology or chemistry is an advantage. We seek students interested in industrial problems, motivated to do experiments and interested in connecting large scale material properties to materials micro- and nanostructure. The student will collaborate closely with PhD candidates and SINTEF as part of the TEM group and in SFI PhysMet.

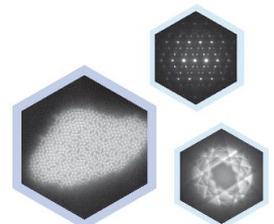
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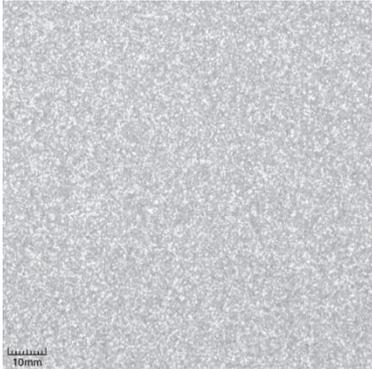
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Investigating the effect of Cu on spangling for extruded aluminium alloys - Internship with YKK in Japan!

Motivation



Aluminum (Al) extrusions may have a defect called 'spangling' that occurs during surface treatments. Spangling makes the surface look less shiny and is a change in brightness at the grain level. It is caused by differences in corrosion resistance, such as ease of etching, which forms surface irregularities and changes the angle of light reflection. Corrosion resistance at the grain level is thought to be affected by copper (Cu) that is dissolved within the grains. Two methods are suggested to reduce the amount of dissolved Cu, these are deformation and heat treatment. By deformation and heat treatment precipitation is promoted, and the amount of dissolved Cu is reduced. By changing temperature and/or time of heat treatment, the amount of dissolved Cu is uniformly reduced. In either method, there is a concern that corrosion resistance may decrease.

Your project

A 4-5 weeks internship is planned at YKK in Kurobe, Japan, preferably in August-September 2026 (see next page). You will then see industrial production, get the material and start the studies, which will be continued when back in Trondheim. The planned studies are microstructural investigation of a 6063 extruded aluminium alloy with Cu content of 0.03 to 0.10 wt.%. The relationship between crystal orientation and grain morphology should be studied, combining electron backscattered diffraction (EBSD) and surface roughness measurements. Changes in structure and composition will be studied by transmission electron microscopy (TEM) – where precipitation, solubility amount, changes in intragranular and grain boundary composition will be studied in detail. Similar structural changes in strained material and overaged material will be examined.

Requirements

The student should be interested in materials science and materials physics, electron microscopy and diffraction – and want to go to Japan! 😊 You should enjoy both independent lab work and collaboration. We seek students interested in industrial problems and motivated to do experiments to connect large scale material properties to materials micro- and nanostructure.

Contact persons

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Tetsuya Katsumi (勝見 徹也), YKK, t-katsumi@ykk.com



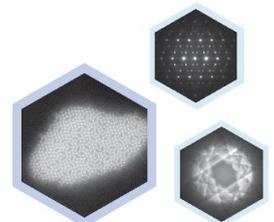
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Why don't you try INTERNSHIP in JAPAN ??

Special Offer from
YKK Corporation, Technology and Innovation Center !!

?? What is YKK ??

YKK Group is manufacturing **Zipper and Extrusion products**.
We have expanded our business all over the world that we have **118 subsidiaries in 70 country/region**.
We call our manufacturing policy as **"integrated production"**.
We are committed to improving the environment from materials.
TIC is researching and developing materials, production equipment, dies and mold as well as analysis and simulation.
We do collaborative researches with University of TOYAMA.



Green Al

Recycle Al



?? What will I do during internship ??

Research and Development of Aluminum alloy used for Extrusions and Zippers



?? When will start ??

Starting August 2026

?? Conditions ??

No compensation. YKK will provide a place to stay and meals during your stay in Japan

?? Where will I stay ??

Kurobe city in Toyama prefecture, J a p a n

?? Who can apply ??

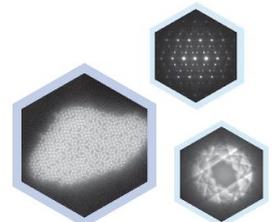
Master's students

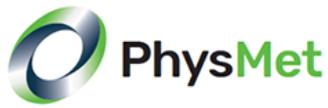
?? How can I apply ??

Please contact Professor Randi Holmestad : randi.holmestad@ntnu.no



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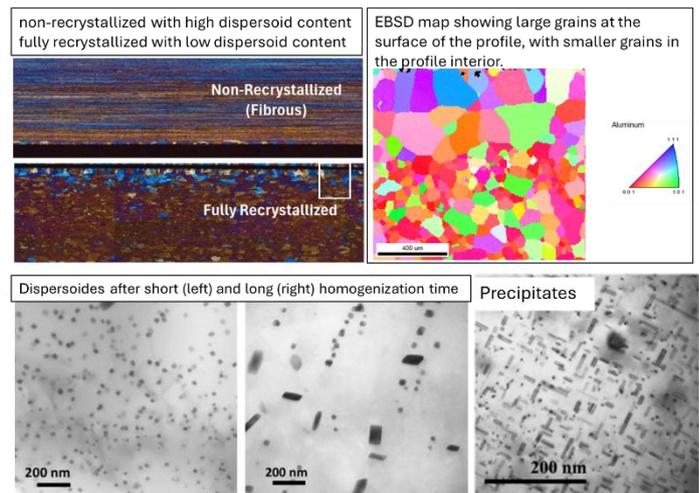




Characterization of dispersoids and precipitates in Al alloys for modified texture

Motivation

6xxx alloys are typically extruded into their final shapes, having main alloying elements Mg and Si. Mg and Si (and Cu) form nanosized precipitates during heat treatments around 200 °C which are the main contributors to strength in these alloys. However, Mn- and Cr- are also often added to certain 6xxx alloys in order to form dispersoids during homogenization (heat treatments around 500-600°C). Dispersoids are often desirable to inhibit recrystallization after extrusion, thereby creating so-called fibrous (non-recrystallized) grain structures. There will however usually be a recrystallized layer of grains at the surface of such extruded profiles. The width of this recrystallized layer can have a huge impact on mechanical properties and corrosion resistance and is mainly determined by dispersoid size/distribution and precipitates and extrusion parameters. This project aims to investigate the effect of dispersoid distributions on recrystallized layer thickness and texture, and consequently link this to the effect on mechanical properties and corrosion



Optical, SEM and TEM images of grain structure, dispersoids and precipitates in an extruded 6xxx aluminium alloy.

Your project

The student will do experimental work on two alloys with different Cr content homogenization cycles, to investigate dispersoid size- and number density, possibly also chemical composition of dispersoids, in addition to precipitate densities. This project is a collaboration with a PhD student in Krakow, doing texture with XRD, and at Department of Materials Science and Engineering (IMA), doing modelling, both working with the same batch of alloys.

Requirements

A background in materials science, materials physics, chemistry, or nanotechnology is an advantage. We seek students interested in industrial problems, motivated to do experiments and interested in connecting large scale material properties to materials micro- and nanostructure.

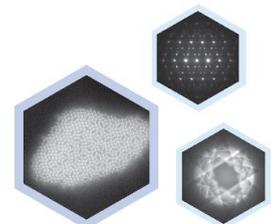
Contact persons

Randi Holmestad, Professor, IFY, randi.holmestad@ntnu.no
Co-supervisor(s): Eva Mørtzell (eva.mortzell@hydro.com)/
Jostein Røyset (jostein.royset@hydro.com)
both at Hydro Research Centre, Sunndalsøra



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TEM characterization of oxide thin films made by pulsed laser deposition

Motivation

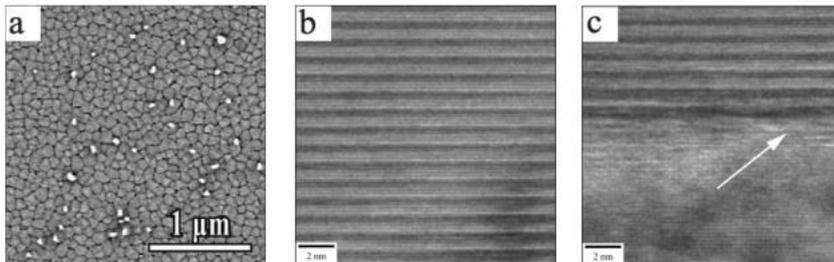


Fig1: a) SEM image of van der Waals material Bi_2Te_3 . b) High-resolution cross-sectional TEM of Bi_2Te_3 film c) HRTEM of the Oxide- Bi_2Te_3 . d) FFT of the interfacial region. The peaks are color-coded and assigned to identified phases. e) EELS profiles of titanium, oxygen, and tellurium across the interface.

Ferrioc materials play a central role in modern information and energy technologies. Their functional properties are strongly tied to their atomic-scale structure, and advanced techniques like TEM allow us to directly probe how these structures behave and interact. At the Department of Materials Science and Engineering at NTNU, long experience with synthesis and characterization provides a strong foundation for exploring such materials. At the same time 2D van der Waals systems are opening new pathways

toward ultralow-power electronic and spintronic devices. In the HONEYCOMB project, hexagonal substrates are used to enable high-quality growth and controlled interfacing of these 2D materials. By combining them with magnetic materials, we can study novel interface phenomena and explore effects such as the quantum anomalous Hall state. This project brings together ferrioc and quantum materials to investigate how distinct material properties interact at well-engineered interfaces. Understanding these interactions offers both fundamental scientific insights and exciting possibilities for next-generation functional devices.

Your project

The student will prepare samples (using Nanolab FIB or other routes) and examine them in the TEM, to support and complement other analyses being performed, and will work in close collaboration with others synthesizing the materials or studying the same materials with other techniques. There is a large activity at Gløshaugen on characterization of functional materials, and the student will be included in these activities, with participation in weekly lunch meetings etc.

Requirements

We seek students with background from physics, materials science or nanotechnology, interested in solid state physics/chemistry and/or nanoscience. If you are interested in experimental work, working independently and collaborating with the research groups synthesizing the materials/devices, please contact the advisors listed below.

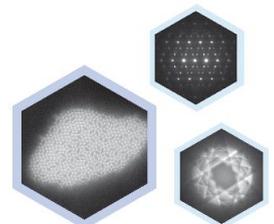
Contact persons

Per Erik Vullum (per.erik.vullum@sintef.no)
and Ingrid Hallsteinsen (ingrid.hallsteinsen@ntnu.no)
from Department of Materials Science and Engineering.



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Extracting meaningful insight from multidimensional TEM data

Motivation

The advances made in data technology have made the terms *big data* and *machine learning* more than just buzzwords. In daily life, big data and machine learning are steering us in the background (e.g. with search engines) and will be even more used in the future (e.g. Google car). In nearly all research fields a disruptive transformation is ongoing due to these advances.

In the TEM group we have been working on new ways to analyze scanning electron diffraction data (ie acquiring 2D diffraction pattern at each pixel). Group members on all levels, including project students, have contributed to recent progress. The new TEM enables acquisition of multidimensional data sets with nm-scale imaging, diffraction and spectroscopy using the latest detector technology. New ways are needed to be developed to handle the growing amount and complexity of data and utilize the complementary information. Work on analyses of such data is part of ongoing research and international collaboration to achieving smart data acquisition and data handling.

Your project

You will get multidimensional TEM data sets, starting with a scanning electron diffraction and energy dispersive spectroscopy data, develop and test new routines and algorithms for the analysis of the given data. The aim is to link crystal phase or orientation analysis to compositional data from the same volume. The data could be from semiconductor material, nanoparticles, or aluminium-alloys. In addition, there is special interest in establishing routines for analysis of beam-sensitive non-crystalline materials, e.g. biomaterials and plastics. Then there is a hard limit how many electrons in the beam can be used to get a meaningful multidimensional insight into the material. Collaboration with the data-owner, taking part of new experimental sessions, and understanding the physics behind the crystallography data can be important.

The created digital tools should be made available and accessible to other people in the research community via open-source platforms, primarily by including developed code via Git into the repositories HyperSpy, pyJEM or pyXem. This means that the whole process of development also must address implementation, version control, testing and documentation. The project can be adjusted to 15, 30, 45 or 60 ECTS.

Required from the student

You should have an interest in using and further developing software tools. Experience with Python and Git is essential. Good communication and interaction with scientific and academic staff and PhD students involved, as well as the skill to work independently, are also important. The intention is that results will contribute to scientific publications. The expertise you will gain during this project should be attractive for jobs outside the field of material physics, as the tools and skills can be applied to challenges in several fields.

Contact person:

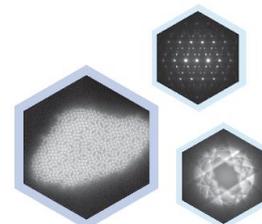
Ton van Helvoort (a.helvoort@ntnu.no)

Others involved: Emil Christiansen (emil.christiansen@ntnu.no), Ursula Ludacka (Ursula.ludacka@ntnu.no), Magnus Nord (Magnus.nord@ntnu.no) and Randi Holmestad (randi.holmestad@ntnu.no)



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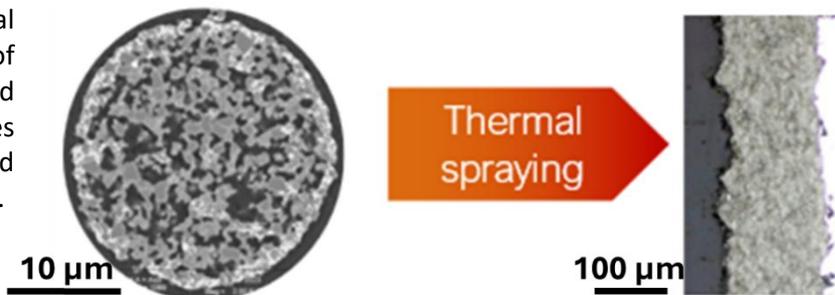
TEM characterization of ThermaSiC

Background

Silicon Carbide (SiC) is a synthetic mineral containing silicon and carbon. It is one of the world's hardest materials, and lightweight. Thermal spraying techniques are coating processes in which melted materials are sprayed onto the surface.

ThermaSiC is [Seram Coating's](#) unique product which enables SiC to be applied as a coating by atmospheric

thermal spraying. The coating can prevent wear, corrosion and withstand high temperatures – it is applied in many applications and surface properties can be engineered (see [article in TU](#)). The coating is produced through complex chemical thermal processes, including a layer of Al and Y (YAG) as a precursor which protects the SiC particles during the thermal spray process. Seram Coatings has contacted us to get more insight into the nanostructure of this powder. This project will study the spray coated protection layer at the nanoscale using transmission electron microscopy (TEM) to identify and understand where in the process segregation patterns and inhomogeneities which impact the final properties are generated.



Your project

You will work with ThermaSiC coating produced by Seram Coatings which has never been studied by TEM before. Samples will be produced by Focused Ion Beam (FIB). You will learn TEM, do chemical mapping at the micro- and nano-scale and investigate phase compositions and elemental segregations via energy-dispersive X-ray spectroscopy (EDS). You will look for pores and inhomogeneities and acquire diffraction patterns to recognize phases, determine orientation relationships and grain sizes – When data is acquired, you will analyze data obtained using data analysis software (like [Hyperspy](#) etc.). **Seram Coating will offer a summer job in Porsgrunn and Trondheim.**

Requirements

The student should be interested in materials physics, electron microscopy and electron diffraction. Experience with programming, preferentially python, is an advantage. Relevant courses are Solid State Physics, Nanotools, and Materials Physics. It is important to be willing to work both independently and in cooperation with other researchers in the project. The student will collaborate closely with Seram Coatings and others in the TEM group.

Contact persons

Randi Holmestad, Professor, Department of Physics, NTNU.

Office: Realfagbygget D4-153, randi.holmestad@ntnu.no

Per Erik Vullum (per.erik.vullum@sintef.no)

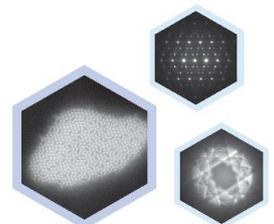
This project is in collaboration with Seram Coatings in Porsgrunn

Stian Sannes stian.sannes@seramcoatings.com



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Structure determination via 3D electron diffraction - *tomography in reciprocal space*

Motivation

Three-dimensional electron diffraction (3DED), or MicroED, is one of the hottest topics in electron beam analysis as it is relatively cheap, can be automated, leads to new discoveries in the fields of minerals, catalysis and pharmacology. Using an electron beam, very small volumes can be characterized beyond what is possible with any other technique. From a tilt series of electron diffraction patterns, i.e. electron diffraction tomography, the crystal structure of a nanoparticle can be determined, including the position of the atoms within the unit cell. This requires careful data processing and analysis and considering deviations from the ideal structure and dynamic diffraction effects. With assistance of a world leading group at Stockholm University, we established Norway's first 3DED set-up. Data collection is fast, but the data processing workflow is under development to make the approach robust.

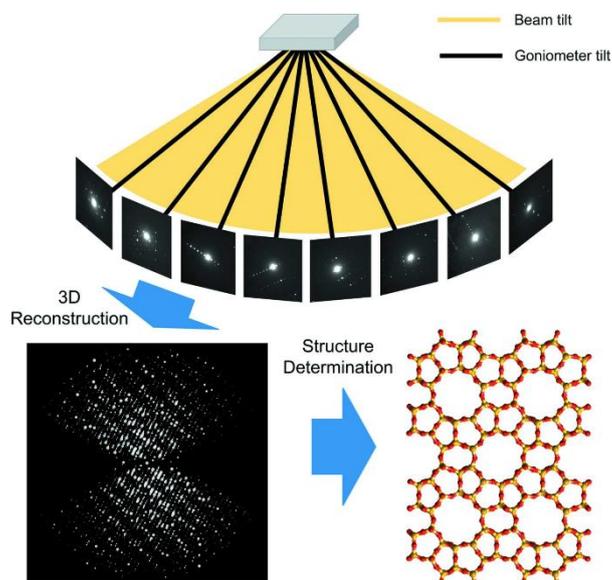


Illustration of the rotation electron diffraction (RED) method from [Wan, Wei, et al. J Appl Cryst 46.6 \(2013\): 1863-1873.](#)

Your project

You contribute in establishing a more solid, smooth and powerful data processing workflow working on twinned TiO_2 . You will learn a bit more crystallography as well as data analysis using a series different platforms to solve a crystal structure. You will collaborate with researchers and postdocs collecting the data and develop the structure development routines. It is expected that you improve the digital tools and that these could be made available via open-source repositories. The work is leading to combine 4D-STEM and 3DED. The projects can be adjusted to 15, 30, 45 or 60 ECTS and expanded to a Master.

Required from the student

You should have an interest in using and further developing software tools, applying and extending your knowledge on basic crystallography and diffraction physics. Experience with Matlab, C++ or preferably Python and finding your way in new packages is essential. Good communication and interaction with scientific and academic staff and PhD students involved, as well as the skill to work independently, are also important. The expertise you will gain during this project should be attractive for jobs outside the field of material physics, as the 3DED processing tools and skills can be applied to various fields.

Contact person:

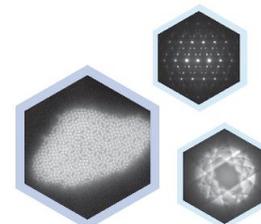
Ton van Helvoort (a.helvoort@ntnu.no)

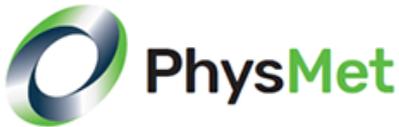
Others involved: Magdalena Cichocka



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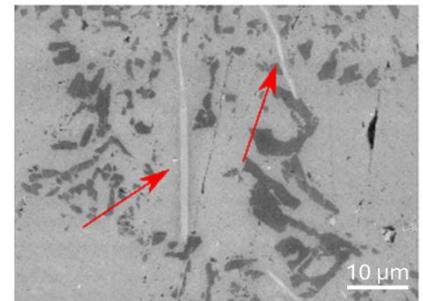




Structure determination of Al-Mn-Ti-Si intermetallic phases via 3DED

Motivation

When aluminium is recycled, we get increased content of alloying elements which degrades properties. One of the ongoing activities in SFI [PhysMet](#) is to investigate the effect of increased levels of iron (Fe) on the microstructure of an AlSi11MnMg foundry alloy. This alloy is often used in the automotive industry for producing parts due to its good castability and strength. We have identified a new iron-rich intermetallic phases that can form in Al-Si cast alloys which is detrimental to mechanical properties, due to its plate-shaped geometry. We found that the formation of these particles is highly sensitive to both iron content and cooling rate during casting. Interestingly, higher Fe can suppress plate morphologies under certain cooling conditions, offering new strategies for microstructure control in recycled Al-Si alloys.



Scanning electron microscopy-backscattered image of plate-shaped particles.

We want to study this phase and solve the structure using three-dimensional electron diffraction (3DED), also called MicroED, 3DED. From a tilt series of electron diffraction patterns, i.e. electron diffraction tomography, the crystal structure of a nanoparticle can be determined, including the position of the atoms within the unit cell. However, this approach is not plug and play and requires development from the sample preparation stage to the atomic position refinement. This requires careful data processing and analysis and considering deviations from the ideal structure and dynamic diffraction effects. The TEM Gemini Centre is in process of developing and improving the 3DED method, and we have already collected the first data from intermetallic phases containing Al,Mn,Si and Al,Mn,Ti. The activity relates to RA3, where previously unreported phases have been produced upon casting aluminium alloys.

Your project

You will get 3DED dataset(s) from the intermetallic phase, analyse this and help to establish a more robust and smooth data processing workflow. This will require using crystallography and data analysis using different platforms to find the crystal structure. You will collaborate with researchers in the TEM Gemini Centre. We want to get two MSc students who can work together on 3DED. It is expected that you improve the digital tools and that these made available via open-source repositories. The project can be 15, 30, 45 or 60 ECTS and expanded to a Master.

Required from the student

You should have an interest in using and further developing software tools, applying and extending knowledge on basic crystallography and diffraction physics. Experience with programming is an advantage.

Contact persons:

Sigurd Wenner (sigurd.wenner@sintef.no)

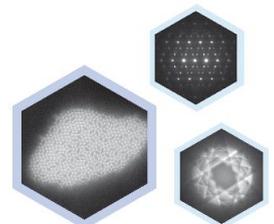
Randi Holmestad (randi.holmestad@ntnu.no)

Ton van Helvoort (a.helvoort@ntnu.no)



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Orientation mapping of nanocrystals- *use analytical skills to describe crystals in three dimensions*

Motivation

The TEM community is taking more and more advantage of computational power and fast new detector technology to record bigger datasets which holds more information. By scanning a fine electron probe (nanometre- to sub-Ångström-sized) and recording a diffraction pattern for each probe position (4D-STEM), a 4D dataset is obtained. Each diffraction pattern can be analysed to get maps giving information on the local crystal structure in the material. At NTNU we have a state-of-the-art setup for one such method which is called scanning precession electron diffraction (SPED). The conventional way of analysing SPED data is based on comparing experiment and simulated patterns and has its limitations. We have worked on a novel alternative method which is based on the underlying physics, referred to as vector analysis. We now aim to generalize the method to handle orientation mapping, starting with a case study on polycrystalline silver. Examples of orientation maps from silver are shown in the figure below. This is a continuation of previous master student projects.

Your project

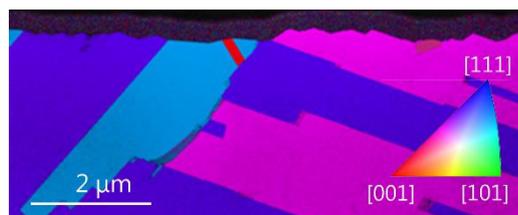
You will get a python code and a relevant dataset from to get familiar with orientation analysis. You will expand a vector analysis code to handle a range of crystal orientations, and we will compare your results to the conventional method of template matching. In the project you will work towards finding the best solution to a hot topic, challenging both your analytical skills and creativity. Your findings will be put into a bigger context, and improvements will likely be part of a publication, presentation at an international conference and/or open-source packages. You can join sessions on the transmission electron microscope to better understand the sample and the data collection. We will organise weekly supervision meetings, and you will be invited and encouraged to join the weekly TEM lunch and the monthly SPED discussion meetings. The project can be adjusted to 15, 30, 45 or 60 ECTS.

Required from the student

We look for a student who enjoys programming and data analysis, at the same time as you happily collaborate and discuss scientific work with others. You should have some basic background with programming in python and value community-based open-source software developments. In this project we will aim to find new and better ways of solving the 3D analytical task, and we will encourage you to share your own thoughts and think outside of the box. While being strong in mathematics, you should also be able to add a touch of creativity. Some familiarity with crystallography and diffraction will be a great advantage. Relevant courses include Numerical Physics, Solid State Physics, and Materials Physics.

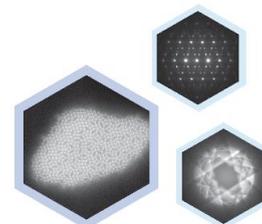
Contact persons

Ton van Helvoort, IFY, a.helvoort@ntnu.no



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Understanding effect of minor elements in graphite nucleation and growth in cast iron

Motivation

Ductile cast iron is one of the most cast materials in the world by market share. Elkem produces ferrosilicon alloys and inoculants to enhance their properties. For that purpose, [inoculants](#) and alloys - ferrosilicon alloys added in very small quantities to induce nucleation (mechanism for initiating graphite formation) of graphite - are added to control the process of solidification and provide the desired microstructure and mechanical properties in the ductile iron castings used in various applications such as for wind turbine components.

Elkem offers a range of premium inoculants supplied globally and has pioneered the development of inoculant specifications for the worldwide iron foundry industry for decades. To keep this position, we need to understand graphite nucleation, which is very sensitive to the nature of the seed (nuclei), cast iron chemistry and solidification rates.

In the case of wind turbine components, solidification may take up to a day to solidify completely and days to cool down. This can lead to several graphite degeneracies (unwanted graphite shapes). The main topic for this master's thesis project is to understand the role of minor elements - amounting to parts per million levels in the final casting - into graphite nucleation and growth in large ductile iron castings.

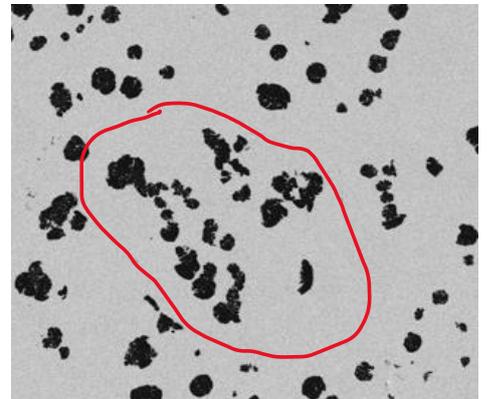
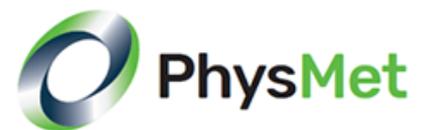


Figure 1: Example of a graphite nodule degeneracy in ductile iron. Source: Prosjektoppgave fra Stian Skinnarland - 2025

Your project

The student will be at the forefront of Elkem's product development endeavors. The student will help gather knowledge on the role of certain elements in cast iron solidification and employ advanced characterization techniques such as Scanning Electron Microscopy, Focused Ion Beam/SEM and Transmission Electron Microscopy to better understand:

- Local chemical composition;
- Crystal structure of nucleation seeds;
- Crystallographic relationship between Seed and graphite;
- Growth of graphite structure.



Requirements

We seek students motivated by the challenge of linking atomic-scale phenomena to industrial scale performance. Background in materials physics, nanotechnology or chemistry is an advantage. For data analysis, knowledge of Python is a big advantage.

Contact persons

This topic is a collaboration with [Elkem Silicon Products](#) – contact us to get more details!
Randi Holmestad (NTNU) randi.holmestad@ntnu.no, Sigurd Wenner, sigurd.wenner@sintef.no
Co-supervisor from Elkem: Bruno Eggert bruno.eggert@elkem.com

Possibility for summer job? Yes



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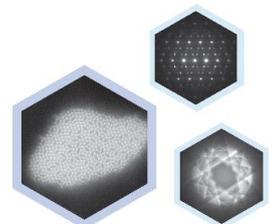
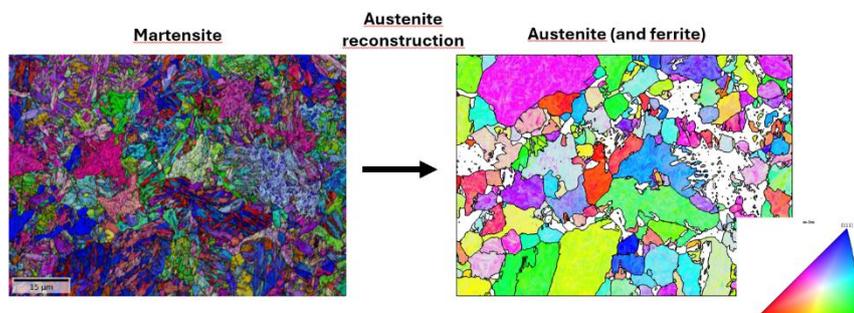




Image segmentation of microscopy data in aluminium alloys and steels

Motivation

Aluminium alloys and steels rely on careful control of chemical composition and thermo-mechanical treatments to achieve optimal mechanical properties. In aluminium alloys, mechanical strength is typically obtained through precipitation of nano-sized crystals during controlled heat treatments. In steels, mechanical strength is influenced by the size and distribution of phases such as ferrite, bainite, and martensite that form when austenite is cooled from very high temperatures. By changing the thermomechanical process route, significant microstructure changes at the nano- and micrometer scale can take place in these materials. These changes, e.g. size, morphology, and spatial distribution of different phases, can be analyzed and quantified from electron microscopy data (SEM, TEM, EBSD, ...). However, this can be very time-consuming. It is therefore vital to develop objective and automatic image segmentation solutions to facilitate the identification and quantification of these microstructure features. This can ultimately enable objective and faster assessments of microstructure features, like for example identification of precipitates in aluminium alloys or reconstructing austenite grains in steels.



Austenite reconstruction from martensite orientation map recorded with EBSD.

Your project

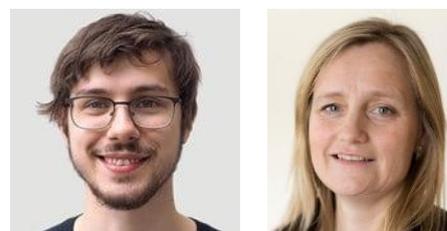
We will provide a dataset of annotated microscopy images. You will help characterize the material based on these images using traditional image analysis and deep learning with convolutional neural networks (U-Net, Mask-RCNN). The results should be discussed in the context of the material's properties, such as its composition, temperature history, mechanical properties and recyclability.

Requirements

We seek students with backgrounds from physics, materials science, nanotechnology, interested in combining computer vision with nanoscience. You should have a basic background with Python programming, and ideally a basic understanding of machine learning. If you are interested in computational work, working independently and collaborating with the research groups on using computer vision, please contact the advisors listed below.

Contact persons

Tor S. Haugland (tor.haugland@sintef.no) and
Randi Holmestad (randi.holmestad@ntnu.no)



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