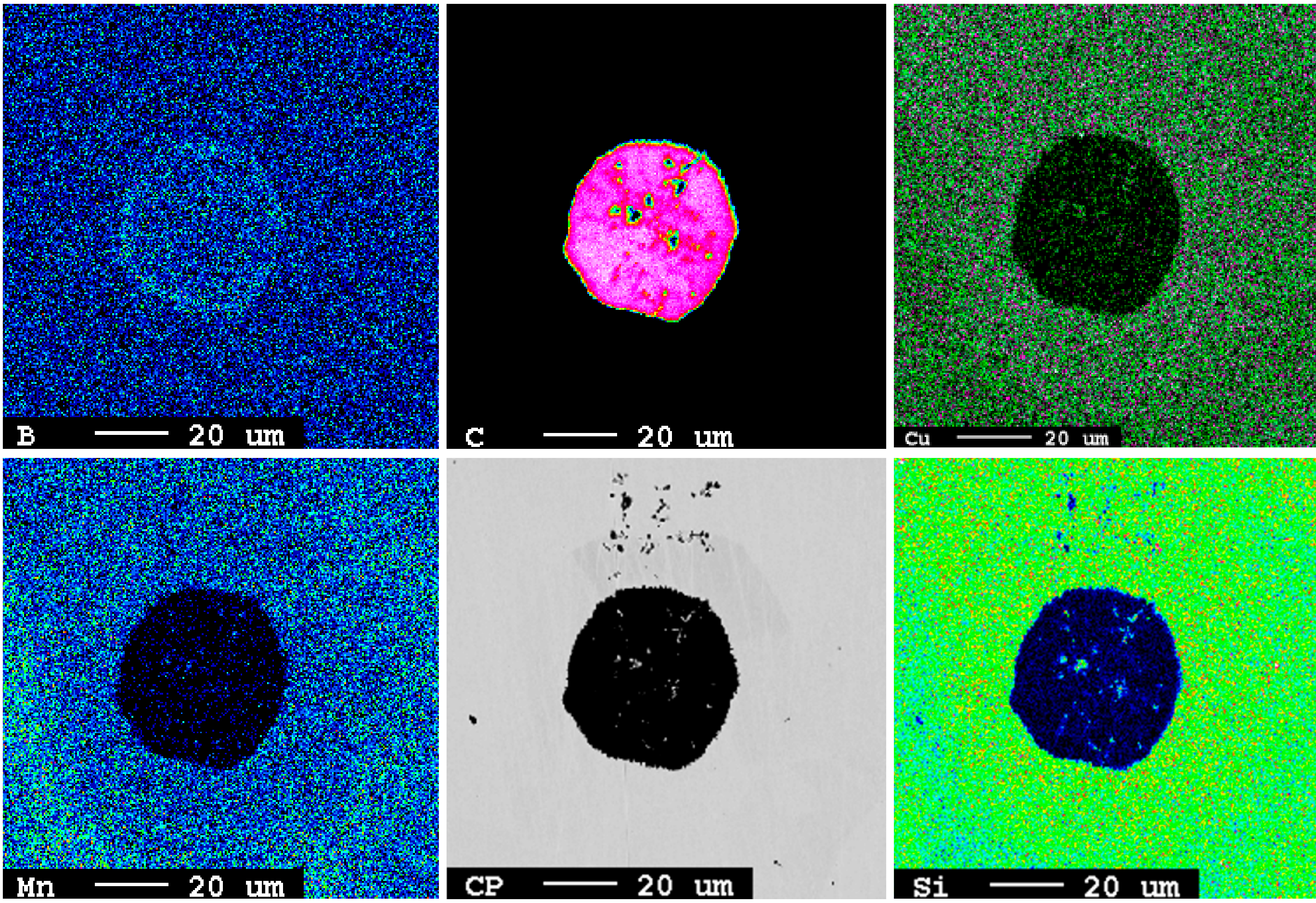
Centre for Sustainable and Competitive Metallurgical and Manufacturing Industry

ANNUAL REPORT
2025

SFI PHYSMET



PhysMet

Norwegian Centre
for Research-based
Innovation

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Elemental maps of a graphite nodule in cast iron, obtained using electron probe microanalysis (EPMA). Credit: Morten Peder Raanes, NTNU.

Layout and production: Monika Wist Solli, NTNU Grafisk senter

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SUMMARY

BY CENTRE MANAGER
KNUT MARTHINSEN, NTNU

2025 means that SFI PhysMet is well into the last second half of its 8 years funding period (2020-2028). The 'Half-way Assessment' organized by the Research Council of Norway (RCN), which started in 2024 with a lot of preparatory work to document and report the activities and achievements, was completed in February 2025 with an online meeting with representatives from RCN and the International evaluation panel appointed. In the meeting, activities, achievements and plans were presented and discussed in view of all the success criteria for the SFI funding scheme. The meeting served as basis for the final Evaluation report from the International Panel, which was very favorable for SFI PhysMet, as expressed by the following quote from the evaluation Report:

"SFI PhysMet is one of the leading Physical Metallurgy Centre in the word, recognized internationally. The PhysMet pursues objectives which are very well aligned with the Norwegian industry needs and which are key for innovation and talent development in metal science and industry. The overall assessment of the PhysMet group by the Panel is highly positive."

Based on this very positive Report and feedback, the RCN Innovation Board made the decision that SFI PhysMet could continue, mainly as originally planned.

An important objective for SFI PhysMet is to generate new knowledge and skills and provide useful results that the partners can use in their internal R&D and innovation activities for value creation, increased sustainability and competitiveness. Some selected highlights from 2025 are given below.

Using more recycled aluminium is important for both sustainability and cost reduction. But recycled material often contains small amounts of elements like copper, iron and zinc, which can influence the alloy's behaviour. Using advanced microscopes (TEM and atom probe tomography), we have studied how impurities accumulate at grain boundaries in 6xxx aluminium alloys. We see clear differences in how copper and zinc segregate, and this affects susceptibility to intergranular corrosion – a form of corrosion that can create deep, harmful cracks. Our findings help define how much recycled material can safely be used without compromising the material`s quality and performance. Higher recycling rates also increase the iron content in cast alloys. In 2025, we identified a new type of iron rich intermetallic particle in Al–Si alloys. These phases form only under specific iron levels and cooling rates and can reduce both strength and formability. Understanding these particles is key to controlling – or avoiding – them in future recycling-based production.

At SFI PhysMet, we are also developing new aluminium alloys for defect-free 3D printing. By fine tuning the process and using optimized grain refiners, we succeeded in 2025 in printing high strength aluminium alloys without cracking – a major step toward broader industrial adoption of metal additive manufacturing. We also study a promising welding technique Laser–Arc Hybrid Welding (LAHW), for large steel structures, highly relevant for wind energy components. By controlling preheating and/or additional filler material, we show that high impact toughness can be achieved in 45 mm thick steel plates through a favorable microstructure dominated by acicular ferrite. Finally, in 2025, the digital platform was expanded with a FAIR compliant knowledge base. This makes research datasets easier to understand and reuse — for both humans and machines.

Yet an important objective of SFI PhysMet is the training and education of master and PhD candidates with state-of-the art competence and skills in the field of physical metallurgy in general and on the focus areas of SFI PhysMet in particular. The PhD defense of Andreas Voll Bugten in December 2025 was an important milestone for SFI PhysMet, as the first fully funded PhD candidate by the SFI. The PhD work of Andreas Bugten was related to cast iron, which strength and toughness come from tiny, usually round, graphite particles formed as the iron cools. Recycled steel is often added to cast iron for cost and environmental reasons, but this can introduce unwanted elements like boron. Even in small amounts, boron softens cast iron and disrupts the normal graphite shape, harming mechanical performance. The work of Andreas has made significant contributions to the understanding of these effects, as also recognized by the international PhD opponents, and provided a scientific basis for developing strategies to control and mitigate them, and as such provided important knowledge for a more sustainable, scrap-based cast iron industry. The PhD work of Bugten has been carried out in close collaboration with our industrial partner Elkem. We are grateful to Elkem for their support, and their active involvement in the PhD work of Andreas, both through large casting campaigns, for the materials provided and for supervision.

As the first 'wave' of PhDs (and Postdoc) are about to complete their projects and contracts (we look forward to several PhD defenses in 2026), 2025 has also been an active year for the recruitment of new PhD candidates and postdocs/researchers. Three new PhD candidates started in 2025 and two new postdocs / researchers. These new candidates and their research activities are presented in a separate section later in this Annual Report.

Summer jobs and student projects are also valuable 'tools' for effective and productive collaboration between academia and industry. 14 master student projects were completed in 2025, on activities directly originating from the SFI or on topics which are closely related to the SFI activities and in most cases in close collaboration with the industrial partners.

Outreach by communication and dissemination of R&D activities and results are an important responsibility of an SFI. The SFI PhysMet researchers have also in 2025 published a good number of scientific papers, as well as presenting their results at national and international conferences, seminars and workshops. The latter includes a number of keynote- and invited presentations at renowned international conferences, which is important for international visibility and networking. SFI PhysMet also participate in different student events to promote the PhysMet activities and recruit master- and PhD students. One such important event in 2025 was *The Trondheim International Summer School on Aluminium Alloy Technology* (ISSAAT) organized at NTNU in June 2025. The summer school attracted 43 participants (mainly MSc and PhD students, but also from aluminium industry) and 18 lecturers from 9 different countries across the world. While we are continuing our journey in the SFI-PhysMet period, we are pretty sure that also 2026 will be a successful year!

VISION AND RESEARCH STRATEGY

Vision: *SFI PhysMet aims to be a world leading research centre in the field of physical metallurgy, required to accelerate the transformation of the national metal industry towards more sustainable and cost-efficient production and future material products, solutions and improved processing methods.*

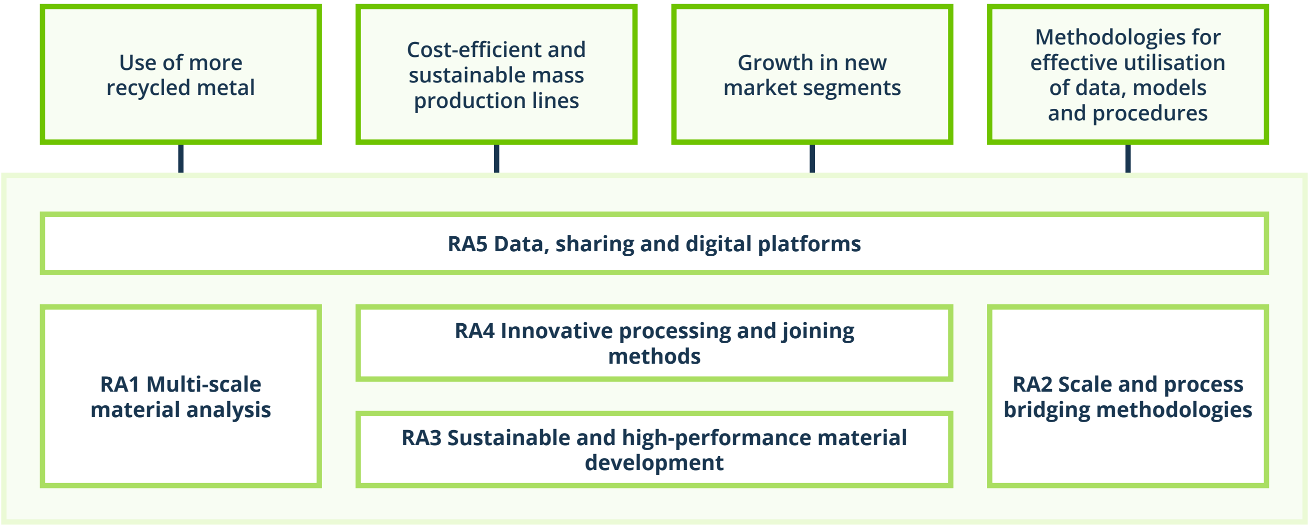
RESEARCH STRATEGY

The energy-demanding land-based industry sectors in Norway, i.e., the *metallurgical and manufacturing industry* have been of vital importance for Norwegian export and national value creation. However, *their presence and future sustainable growth in Norway depend on a competitive advantage in terms of high-technology competence and superior quality in their businesses*. In order to secure their position and prepare for further growth, four main industrial technology challenges that need to be solved to enable future new jobs, competitiveness and sustainable growth have been identified, and described in detail in the SFI PhysMet project description:

- **Use of more recycled metal**
- **Cost-efficient and sustainable mass production lines**
- **Growth in new market segments**
- **Methodologies for effective utilisation of data, models and procedures**

Even though these four main industrial challenges are comprehensive, requiring new innovative alloys, materials and processes, their basic knowledge needs are overlapping and generic. Extensive knowledge is required, about the mechanisms for formation and evolution of microstructures, and about the underlying principles. Then processing routes can be designed or improved, to cost-efficiently provide the desired properties of the products. Progress and innovations are accelerated when the knowledge and associated methodologies, models and data are efficiently stored and made available to academic and industrial researchers and engineers in the Centre.

The chart on next page illustrates the structure of SFI PhysMet, for which five *Research Areas* (RA1-RA5) are designed to meet the targeted industrial knowledge needs. Material characterisation in RA1 and modelling in RA2 represent the basic research required for developing the desired material design in RA3 and innovative processing in RA4. A separate RA5 is dedicated for developing a platform for storage and



sharing of data and models, facilitating accelerated progress in RA1-RA4 and making results available for exploitation.

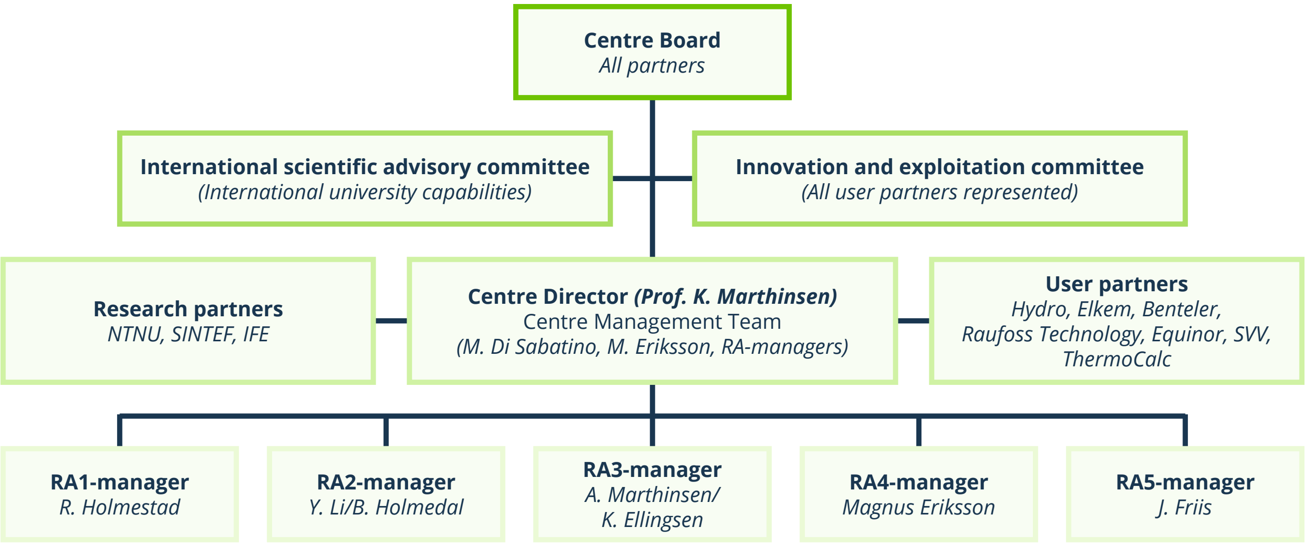
The targeted industrial knowledge needs serve as the basis for the specific research activities in each Research Area as further described later in this report.

SFI PhysMet has now passed the midpoint of its funding period (2020–2028). The overall objectives remain valid, but their realization requires updated priorities and adjustments to the original project plans. These changes reflect the progress achieved so far, evolving industrial needs, and emerging trends in materials science and engineering relevant to the Centre. Key developments include:

- **Stronger emphasis on sustainability**, including increased use of postconsumer scrap and low-carbon materials, and understanding how these affect microstructure, processing, and performance.
- **Norway's ambitious green-energy targets**, such as 30 GW offshore wind by 2040, which increase the importance of advanced joining technologies (e.g., laser beam and hybrid laser-arc welding) to reduce manufacturing costs.
- **Elkem's investment in a full-scale powder atomizer**, calling for systematic studies of powder structures and properties.
- **Rapid growth of additive manufacturing (AM) in Norway**, supported by a developing national AM ecosystem. With rising demand for digital inventories and energy sector components, AM is becoming essential for on-demand production, repair, and refurbishment. This creates a need for new materials, processes, and digital tools to ensure consistent quality and first-time-right production.
- **Growing impact of machine learning**, particularly surrogate models that provide fast, system-independent alternatives to computationally intensive physical models. Physics-informed and scientific machine learning approaches are also advancing, enabling better modelling of complex phenomena and revealing previously unknown relationships.
- **Increasing relevance of semantic technologies** for knowledge integration and cross-disciplinary data sharing, driven by the needs of the green transition and AI development. The Centre will monitor this area closely, assessing the tool`s maturity and updating the platform annually to incorporate the most suitable semantic-based documentation and integration solutions.

An important objective is user partner involvement and their active participation in the research activities to make the research results relevant for the partners and to support their own research and innovation activities. To realize these objectives, the research plans are developed in dialogue with the user-partners. Most PhD projects are also planned and run in close collaboration with one or more user partners, and often with at least one co-supervisor from industry. Finally, a large number of master student projects are initiated from and carried out in close collaboration with the user partners on industry-relevant problems.

ORGANIZATION



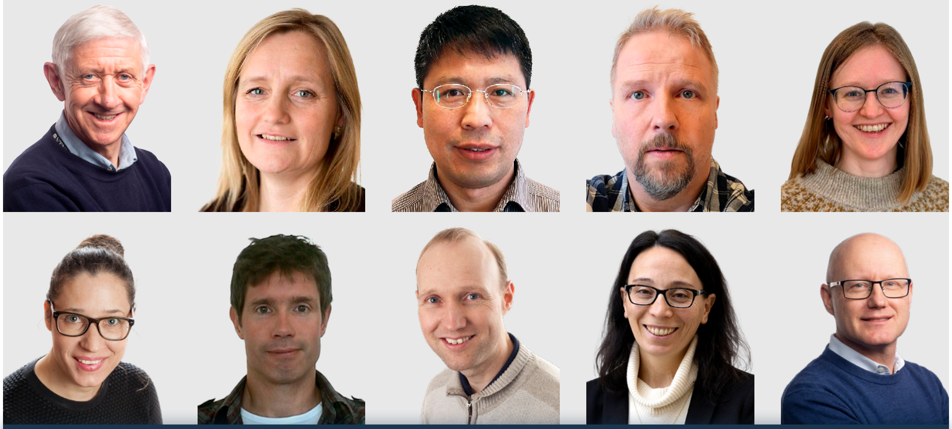
THE CENTRE BOARD

Board meetings are held at least twice a year. The board's main responsibility is to ensure that the intentions and plans underlying the contract for the establishment of the centre are fulfilled. The board is to ensure that cooperation proceeds smoothly between the centre, the host institution and the partners in the consortium.

MEMBERS OF THE BOARD ARE:
Nina Dahl, SINFEF Industry (Board leader)
Erik Wahlström, NTNU
Trond Furu, Hydro
Gro Eide, Elkem
Lars Lodgaard, Benteler
Gotthard Mälzer, Equinor
Jørgen Li, Raufoss Technology
Cato Dørum, Statens Vegvesen
Anders Engström, Thermo-Calc Software
Tanja Pettersen, SINTEF Industry
Øyvind Jensen, IFE
Øystein Asphjell, NFR (observer)

THE CENTRE MANAGEMENT TEAM

The centre manager is Knut Marthinsen. Co-manager is Marisa Di Sabatino and administrative coordinator is Torleif Nordskog. Magnus Eriksson represents SINTEF in the management team. The five Research Area (RA) leaders are also part of the management team.



First row: Knut Marthinsen (NTNU, director), Randi Holmestad (NTNU, RA 1 manager), Yanjun Li and Bjørn Holmedal (NTNU, RA 2 managers), Astrid Marthinsen and Kjerstin Ellingsen (SINTEF, RA 3 managers). Second row: Magnus Eriksson (SINTEF, RA 4 manager), Jesper Friis (SINTEF, RA 5 manager), Marisa Di Sabatino (NTNU, co-director) and Torleif Nordskog (NTNU, administrative coordinator).

PARTNERS

User partners: SFI PhysMet's user partners include metal and material producers, downstream material processing industries as well as end users of metals and alloys. The user partners are: Equinor, Hydro, Elkem, Benteler, Raufoss Technology, Thermo-Calc Software and The Norwegian Public Roads Administration

Research partners: NTNU, SINTEF and IFE

THE SCIENTIFIC ADVISORY COMMITTEE

In order to secure that the centre activities hold an excellent scientific standard and that we are closely connected with leading scientific groups in metallurgy around the world, we have appointed a scientific advisory committee (SAC). The members of SAC are:

Professor
Dierk Raabe,
Max Planck Institute for Iron Research, Düsseldorf, Germany

Professor
Aude Simar,
UC Lovain, Belgium

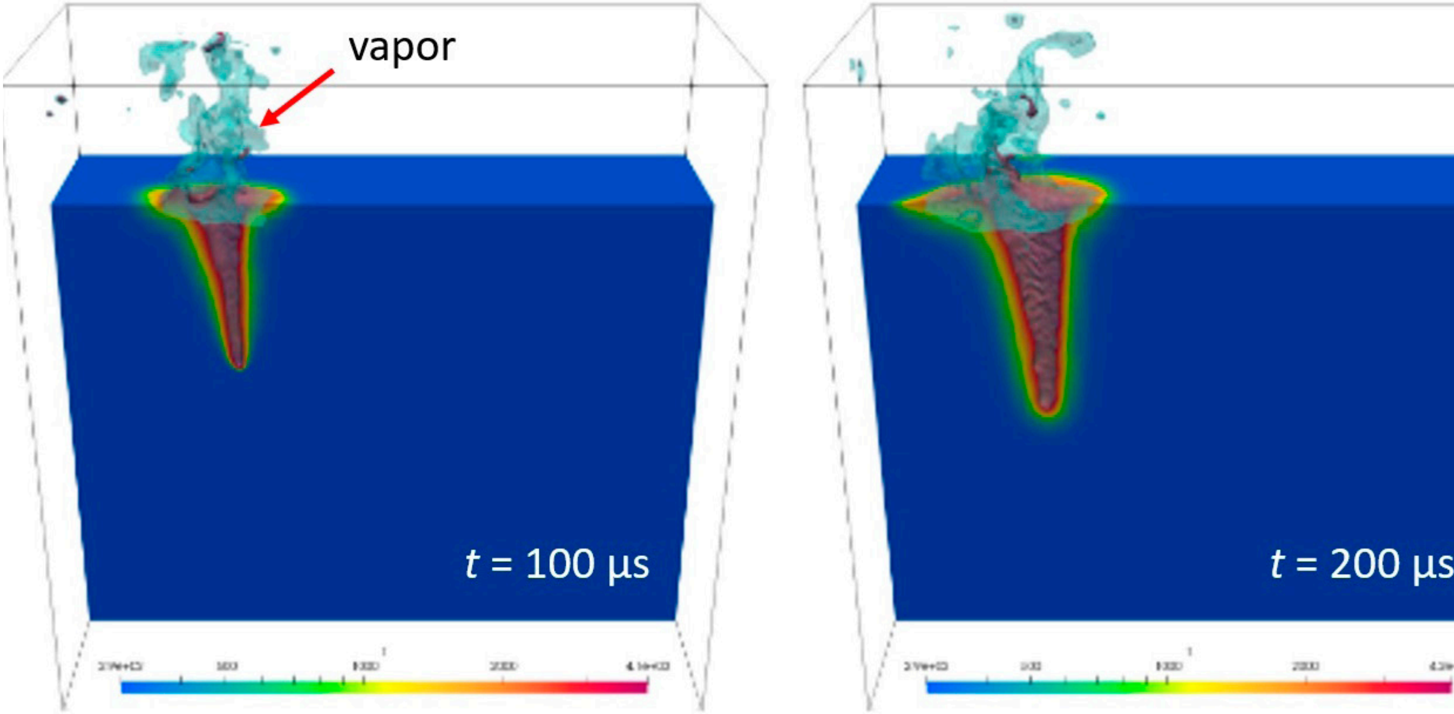
Professor
Dorte Juul Jensen,
DTU Technical university of Denmark

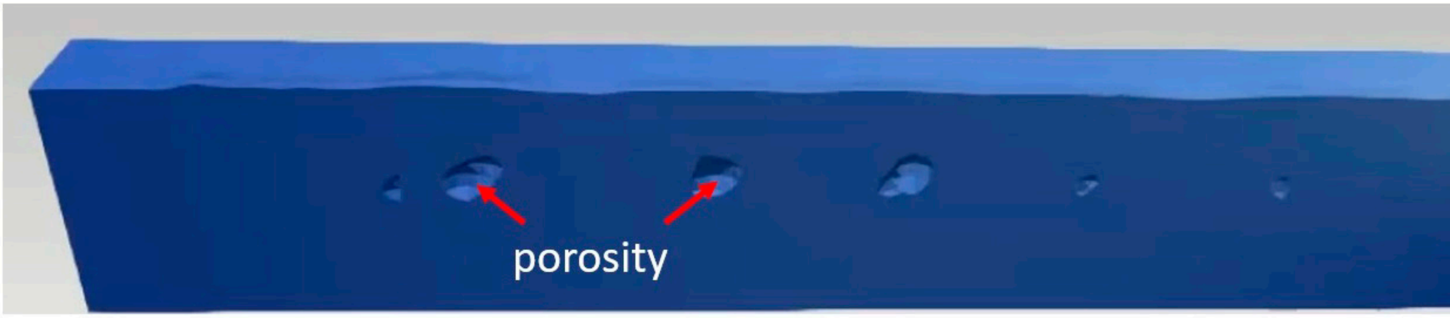
LOCATION

SFI PhysMet is hosted by NTNU, Department of Material Science and Engineering. The managers of the centre's five research areas work in Trondheim at campus Gløshaugen and at SINTEF Industry in Oslo. The centre is located at campus Gløshaugen, with offices available for all research- and industry partners. PhD candidates and Postdoctors recruited to the centre work closely together and with short distance to the project leaders and supervisors. The co-location in Kjemiblokk 1 ensures effective collaboration between the research groups.

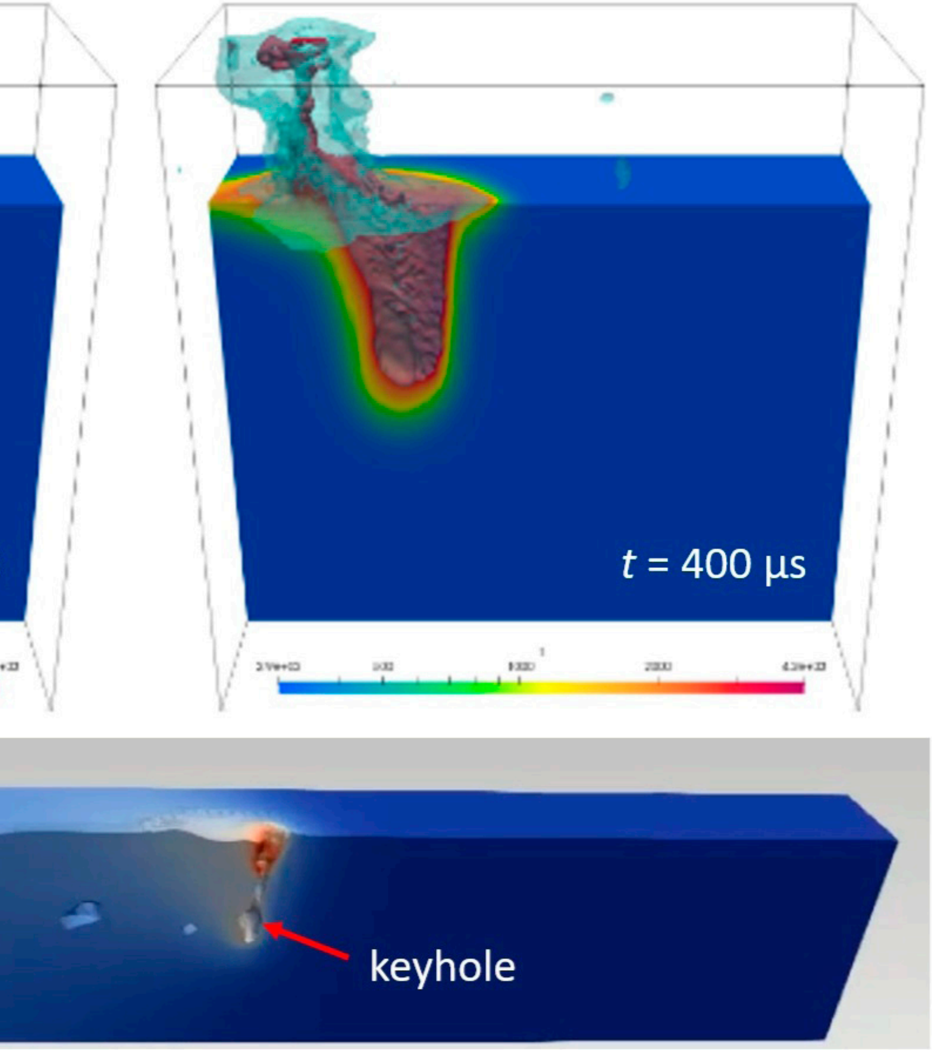
Campus Gløshaugen, Trondheim

SCIENTIFIC ACTIVITIES AND RESULTS





The following pages give a brief overview of our Research Areas in terms of contributions to the centre objectives, main challenges to be met, research activities with focus on the specific activities performed in 2025. The scientific activities are performed at NTNU, SINTEF and IFE, in close collaboration with the user partners.



Numerical modelling of laser beam keyhole welding with vapor phase and laser beam welding of aluminium 6082 alloy plate with advanced adaptive mesh refinement.
Credit: Ivan Bunaziv

RESEARCH AREA 1.
MULTI-SCALE MATERIAL ANALYSES

RESEARCH AREA LEADER:
RANDI HOLMESTAD
NTNU

CONTRIBUTIONS TO CENTRE OBJECTIVES

Production of advanced materials for the future requires detailed knowledge of the structure and chemical composition of materials at several length scales. NTNU hosts a world-class characterization infrastructure that is especially equipped to tackle metallurgical problems. The objective of RA1 is to utilize these instruments to the best for SFI PhysMet.

- Develop a world leading platform and corresponding methodologies for multiscale and multidimensional structure characterization and high-sensitivity chemical analysis of metals, alloys and advanced nanomaterials.
- Contribute to other RAs by providing detailed characterization information, revealing in-depth mechanisms, providing reliable experimental data, and validating through-process modelling.

MAIN CHALLENGES TO BE MET

- Develop correlative use of transmission electron microscopy (TEM) and atom probe tomography (APT). The techniques are complementary and provide experimental data on the crystal structure and chemistry down to the atomic scale - crucial for developing and validating atomic scale simulations and through-process models.
- Develop and establish a framework for multiscale studies of material joints. The multiscale microstructure and complicated chemistry created when materials are joined (by welding or AM) require use of the entire characterization toolbox.
- Establish in-situ characterization techniques. Advanced in-situ characterization tools will be utilized to quantify the kinetics of microstructure evolution during solidification, heat treatment and deformation, at several length and time scales.

ACTIVITIES AND RESULTS IN 2025

There are currently three PhD students (Håkon Longva Korsvold, Inga Dahlen Konow and Thyra Rolfseng). In addition, five MSc students are currently working in RA1 on research topics, which is an integrated part of the RA1 activities. Researchers Sigurd Wenner, Calin D. Marioara, Elisabeth Thronsen and Tor S. Haugland have contributed from the SINTEF side. RA1 is organized into research tasks, and we had activities in seven of them in 2025. In addition, we did some characterization work for the other RAs. A selection of the results obtained in 2025 are described in the following.

Multiscale studies of materials joints

Microstructure in MIG-welded high-strength 7xxx (Al-Zn-Mg(-Cu) plates from Benteler have been studied to understand the effect of the heat affected zone (HAZ) has on properties like hardness, stress corrosion cracking (SCC) and intergranular corrosion. Size and distribution of precipitates present on the grain boundaries (GB), segregation of elements to the GB as well as width and composition of precipitation free zones (PFZs) are important quantities. These quantities are studied in SEM and TEM, by Sigurd Wenner. Liesbeth Campbell and Thyra Rolfseng, and a paper is planned. Moreover, Liesbeth Campbell is working on her MSc thesis of wire arc additive manufactured (WAAM) 5183 of screw extruded wires with TiC nanoparticles, and growth of TiAl3 particles in collaboration with RA4.

APT and TEM of precipitates and grain boundaries
The inclusion of unwanted impurity elements is often unavoidable in the recycling process of aluminium, as secondary aluminium from post-consumer scrap comes with varying compositions. As such, it is important to understand how these impurities affect the alloy properties (in particular corrosion) in order to design high performing alloys containing high amounts of post-consumer scrap.

Copper and Zinc are among the elements commonly used as secondary alloying elements in Al-Mg-Si alloys; both elements have been found to individually decrease the resistance to intergranular corrosion. However, the presence of both elements has in some cases been found to mitigate this effect. Ph.D. student Håkon Longva Korsvold have been studying this effect in a series of Cu containing 6xxx alloys with varying Zn levels, using a combination of STEM and APT. It was not found that varying the Zn content affected the bulk strengthening precipitates in the alloy in terms of size, density or structure, it was however found an increase in precipitate Zn content. The precipitates at the grain boundary were however found to change from Cu containing Q-type precipitates at low Zn levels, to pure Mg-Si precipitates at high Zn levels. Q-type precipitates at the grain boundary have previously been linked to IGC-susceptibility. Additionally, a high amount of Cu was found at the grain boundary in low Zn; however, at high Zn levels this was found to be reduced by almost ninety percent.

A similar effect between Cu and Zn has been observed in HPDC Al-Si alloys, where high levels of Cu impurities may cause localized corrosion that propagate along the Al-Si interfaces in eutectic regions, this effect was not observed when Zn impurities were present, heat treatment also removed the corrosion issues. APT analysis found a difference in the composition of these interfaces and the surrounding region depending on the Zn level, which could explain the improved corrosion resistance. For the heat-treated samples, the improved corrosion resistance was linked to a change in the morphology of the eutectic region.

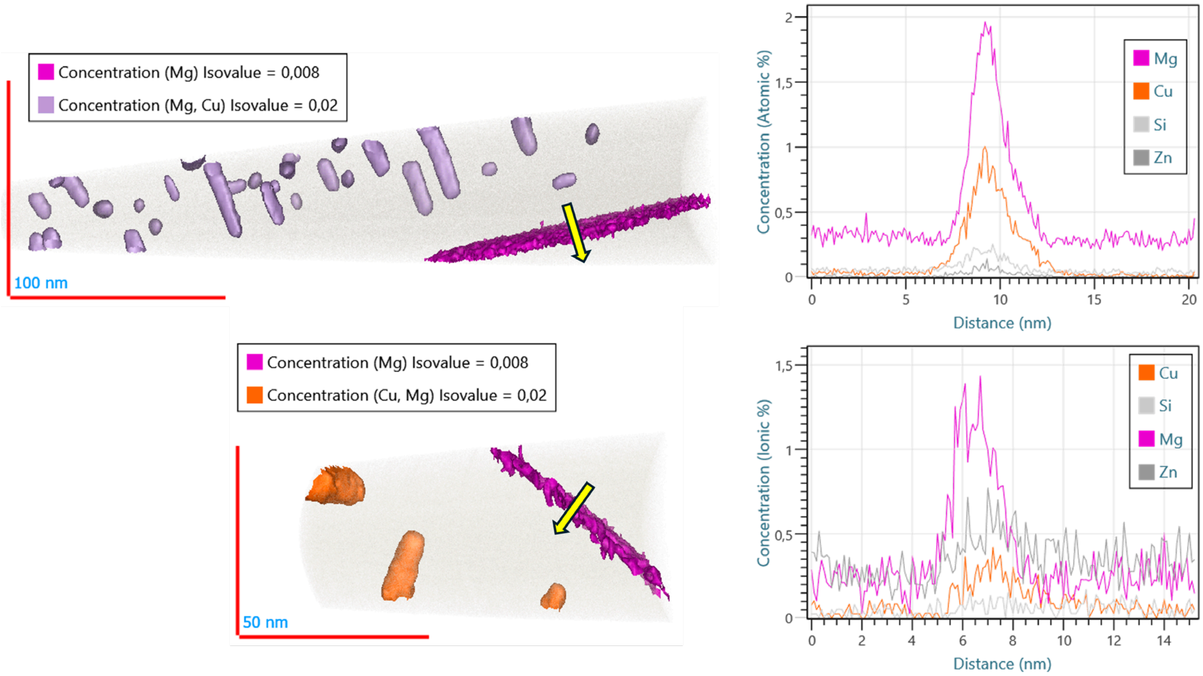


Figure 1: APT datasets of 6xxx alloys with low and high Zn content containing Grain boundaries enriched by Mg and Cu, and the corresponding concentration profiles across the boundaries. The excess Cu at the boundary region is reduced by ~90% in the high Zn sample.

Microstructure studies of extruded 6xxx Al alloys

The demand for high performing recycled aluminium is increasing and with this, a demand to investigate alternative thermomechanical routes that can enhance mechanical properties for recycle-friendly alloys. Inga Konow started her PhD in 2024 and continued in 2025 to study extruded 6xxx alloys from Hydro Extrusions in a T8 temper and a modified T9 temper. These tempers combine cold deformation with age hardening, either by pre-deformation (T8) or by deformation between two hardening cycles. Both the T8 and the T9 temper showed promising results in terms of increasing strength, and although the T8 gave a slight loss in ductility, T9 was shown to increase both strength and ductility. An alloy with 0.1wt.% Zn was also studied, and this alloy showed higher strength, but without the reduction in elongation. This was true both for the undeformed and the pre-deformed condition. To understand the strengthening mechanisms, advanced TEM was coupled with statistical analysis and use of the NaMo model, which consists of both a precipitation model and a strength model.

From precipitate statistics, the strength model in NaMo could be used to estimate the precipitate strength contribution, which gave that in T8, precipitates contributed less to strength than for the undeformed T6. The density increased, but the needles were shorter and smaller, resulting in a similar volume fraction. NaMo could also estimate the dislocation density and thus also the work hardening, which fully explained the strength increase that was observed. The alloy with added Zn was seen to have a higher density, but without the reduction in size, yielding a higher total volume fraction. By using the strength model in NaMo, this increased density was used to explain the measured strength increase.

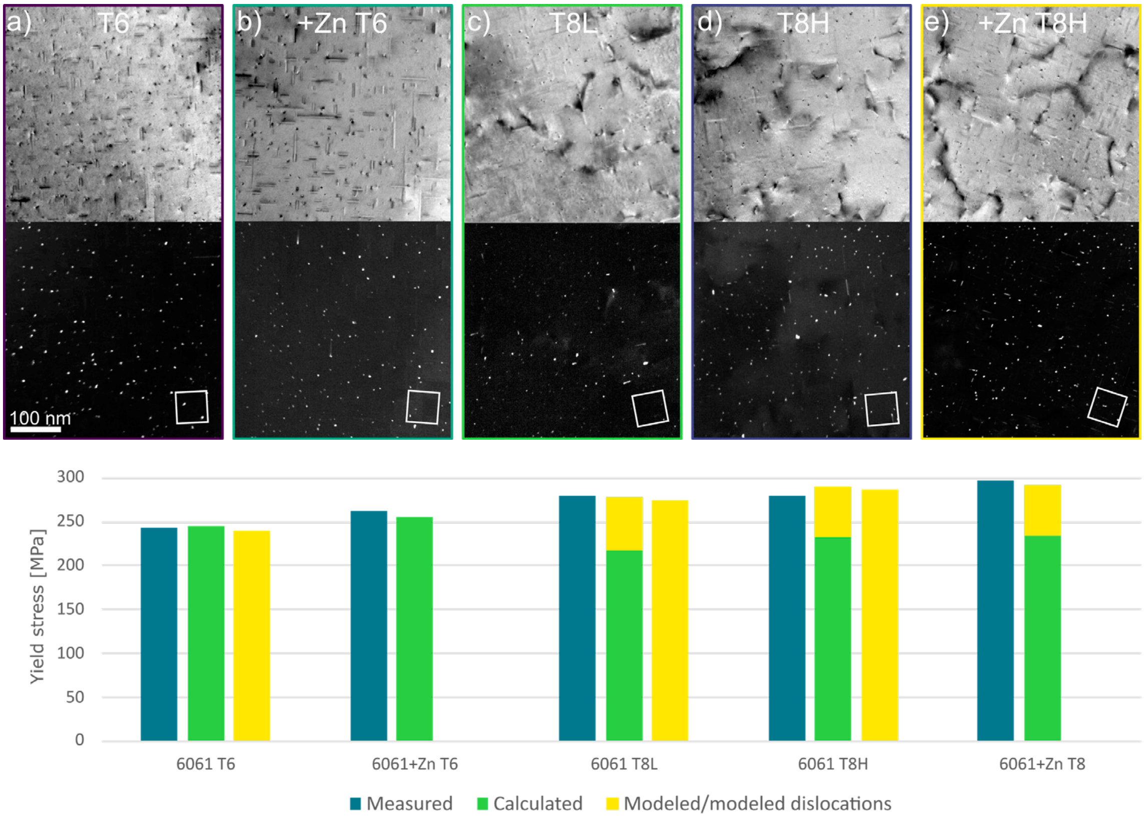


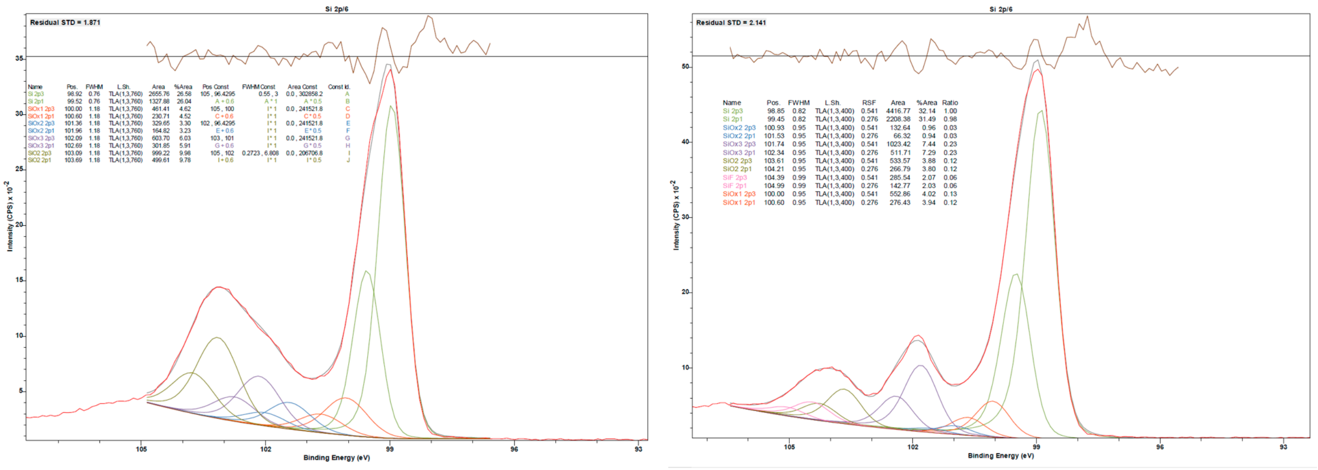
Figure 2: TEM images of indicated samples. All images are acquired near the [001]Al zone axis and have similar thickness (37-49 nm). The in-plane orientation for each sample is annotated with a cube showing the orientation of the aluminum unit cell and the scalebar is valid for all images. Under the measured yield stress, yield stress calculated from precipitate statistics, and modeled yield stress are shown. The modeled contribution from work hardening is added to the calculated bars to allow for direct comparison. The model does not account for the effect of Zn, so the Zn-containing alloys do not have a modeled yield stress.

Oxide layers in silicon powders

MSc student Sophia Wellman investigated the chemical composition of silicon oxide layers on microsized silicon powder using X-ray Photoelectron Spectroscopy (XPS). Silicon powder supplied by Elkem was analysed to gain insight into the surface properties and reactivity of the materials. Sophia compared long-term stored powder with freshly HF-etched powder, determining the relative contributions of different silicon oxidation states. From this analysis, the average oxide stoichiometry was calculated to be SiO1.28 for the etched powder and SiO1.42 for the long-term stored powder. In addition, the XPS results revealed the presence of fluorine on the HF-etched silicon powder, which was not detected on the long-term stored powder, indicating that HF treatment leaves fluorine terminations on the particle surfaces. SEM and TEM studies of the powders served to gain complementary knowledge on particle morphology and the uniformity of the oxide layer.

Precipitate and particle studies using machine learning

In his MSc, Magnus S. Fallmyr studies a dataset of SEM images of aluminium alloys with different compositions and heat treatments produced in RA3. The different phases are characterized based on their contrast and morphology, e.g., eutectic phases and platelets. Here we use the annotated dataset to train a segmentation model (U-Net) to automatically differentiate between phases in a larger non-annotated dataset. The area fractions of the different phases are discussed in the context of the alloy composition, heat treatment, mechanical properties and recyclability.



Name	Pos.	FWHM	L.Sh.	Area	%Area	Pos Const	FWHM Const	Area Const	Const Id.
Si 2p3	98.92	0.76	TLA(1,3,760)	2655.76	26.58	105 , 96.4295	0.55 , 3	0.0 , 302858.2	A
Si 2p1	99.52	0.76	TLA(1,3,760)	1327.88	26.04	A + 0.6	A * 1	A * 0.5	B
SiOx1 2p3	100.00	1.18	TLA(1,3,760)	461.41	4.62	105 , 100	I * 1	0.0 , 241521.8	C
SiOx1 2p1	100.60	1.18	TLA(1,3,760)	230.71	4.52	C + 0.6	I * 1	C * 0.5	D
SiOx2 2p3	101.36	1.18	TLA(1,3,760)	329.65	3.30	102 , 96.4295	I * 1	0.0 , 241521.8	E
SiOx2 2p1	101.96	1.18	TLA(1,3,760)	164.82	3.23	E + 0.6	I * 1	E * 0.5	F
SiOx3 2p3	102.09	1.18	TLA(1,3,760)	603.70	6.03	103 , 101	I * 1	0.0 , 241521.8	G
SiOx3 2p1	102.69	1.18	TLA(1,3,760)	301.85	5.91	G + 0.6	I * 1	G * 0.5	H
SiO2 2p3	103.09	1.18	TLA(1,3,760)	999.22	9.98	105 , 102	0.2723 , 6.808	0.0 , 206706.8	I
SiO2 2p1	103.69	1.18	TLA(1,3,760)	499.61	9.78	I + 0.6	I * 1	I * 0.5	J

Name	Pos.	FWHM	L.Sh.	RSF	Area	%Area	Ratio
Si 2p3	98.85	0.82	TLA(1,3,400)	0.541	4416.77	32.14	1.00
Si 2p1	99.45	0.82	TLA(1,3,400)	0.276	2208.38	31.49	0.98
SiOx2 2p3	100.93	0.95	TLA(1,3,400)	0.541	132.64	0.96	0.03
SiOx2 2p1	101.53	0.95	TLA(1,3,400)	0.276	66.32	0.94	0.03
SiOx3 2p3	101.74	0.95	TLA(1,3,400)	0.541	1023.42	7.44	0.23
SiOx3 2p1	102.34	0.95	TLA(1,3,400)	0.276	511.71	7.29	0.23
SiO2 2p3	103.61	0.95	TLA(1,3,400)	0.541	533.57	3.88	0.12
SiO2 2p1	104.21	0.95	TLA(1,3,400)	0.276	266.79	3.80	0.12
SiF 2p3	104.39	0.99	TLA(1,3,400)	0.541	285.54	2.07	0.06
SiF 2p1	104.99	0.99	TLA(1,3,400)	0.276	142.77	2.03	0.06
SiOx1 2p3	100.00	0.95	TLA(1,3,400)	0.541	552.86	4.02	0.13
SiOx1 2p1	100.60	0.95	TLA(1,3,400)	0.276	276.43	3.94	0.12

Figure 3: High-resolution XPS spectra of Si 2p core-shell electrons from 1) the long-term stored powder and 2) the HF-etched powder. The tallest peak on the far right is signal from elemental silicon (Si^0 - nonoxidised). All peaks to the left stem from oxidised silicon, ranging from Si^1+ to Si^4+ at increasing binding energies.

RESEARCH AREA 2.
SCALE AND PROCESS BRIDGING METHODOLOGIES

RESEARCH AREA LEADERS:

YANJUN LI

BJØRN HOLMEDAL (FROM AUTUMN 2025)

NTNU

CONTRIBUTIONS TO CENTRE OBJECTIVES

- Provide fundamental material data and understanding through high-throughput calculations and simulations from atomistic to microstructure scale.
- Develop and validate specific models for alloy recycling, AM and innovative processing.
- Establish and validate multiscale and multi process modelling framework and AI methods, providing smart design and developing tools of innovative alloys and products.

MAIN CHALLENGES TO BE MET

- How to reach a deeper understanding on the mechanisms and kinetics behind the physical metallurgical phenomena down to atomic scales.
- How to realize computational engineering based smart design of alloys and products with tailored properties.
- How to realize digitalization and automatization of the production in physical metallurgical industry.

ACTIVITIES AND RESULTS IN 2025

There is currently one PhD student (William Frønning Thyholdt), one research scientist (Emre Cinkilic), three PhD (co)supervisors (Bjørn Holmedal, Yanjun Li and Tomas Manik) working in RA2 from NTNU. PhD student Xuezhou Wang submitted his PhD thesis late 2025 (PhD defense 13.02 2026) Researchers Daniel Marchand, Yijiang Xu, Sylvain Gouttebroze, Victor Fachinotti, Kai Zhang and Qiang Du have contributed from the SINTEF side. Some of the results obtained in 2025 are described in the following. The two first topics summarizes the PhD work of Xuezhou Wang.

Atomic scale calculation and simulation -unraveling the kinetics of solute clustering during natural ageing in Al-Mg-Si alloys by a machine learning aided kinetic Monte Carlo simulation

Tiny clusters of alloying atoms that form at room temperature in 6xxx aluminum alloys strongly influence how the alloy hardens during later heat treatment. To uncover how these clusters develop at the atomic scale, a computer model was developed to investigate the motion of individual solute atoms and vacancies inside the aluminum lattice, based on physics rules and assisted by machine-learning techniques. The simulations show that clusters grow quickly at first because a high concentration of vacancies is available to help atoms migrate, but the growth slows down once larger atom clusters begin trapping these vacancies. The model simulations also show that the density of large atom clusters formed during room temperature storage (natural aging) is quite similar for lean alloys and dense alloys containing more Mg and Si contents. This helps to

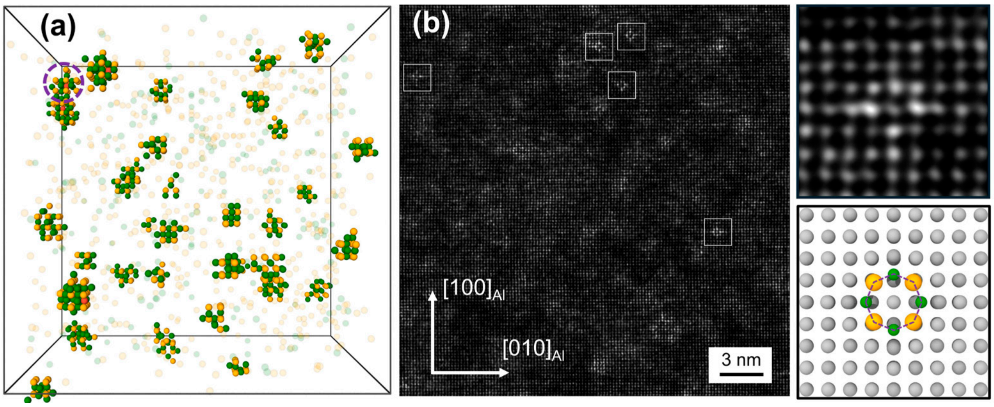


Figure 1. (a) Simulation snapshot of solute clusters containing at least 5 solute atoms and vacancies at natural ageing time of 1000 min. (b) LAADF-STEM image showing bright contrast solute atom clusters and higher resolution representative 'single-eye' GP-zone structure (in the right column).

explain why natural aging effects are more negative for dense alloys: only those large solute clusters (GP-zones) have the chance to develop into β″ precipitates during later artificial aging.

Multiscale modelling of solute clustering kinetics during natural ageing of Al-Mg-Si alloys

After quenching from solution treatment temperature, the strength of Al-Mg-Si alloys continue to increase even after a year of storage at room temperature. This is a typical natural aging behavior driven by forming and slow growth of small solute clusters. To understand this process, a multiscale modelling framework was developed to simulate how solute atoms and excess vacancies interact with each other at room temperature. By a careful treatment of the diffusion of solute atoms under the influence of excess vacancies, formation and growth of solute clusters, vacancy diffusion and annihilation, and the bonding between solute clusters and vacancies, the model can catch the solute clustering kinetics during naturing of commercial 6xxx Al-Mg-Si alloys. The simulated number density and size of solute clusters are in good agreement with experimental measurements. The model has been successfully applied to explain how different quenching rates after solution treatment affect natural-ageing behavior. These insights offer valuable guidance for optimizing alloy processing parameters and therefore improving the mechanical properties of industrial Al-Mg-Si alloys.

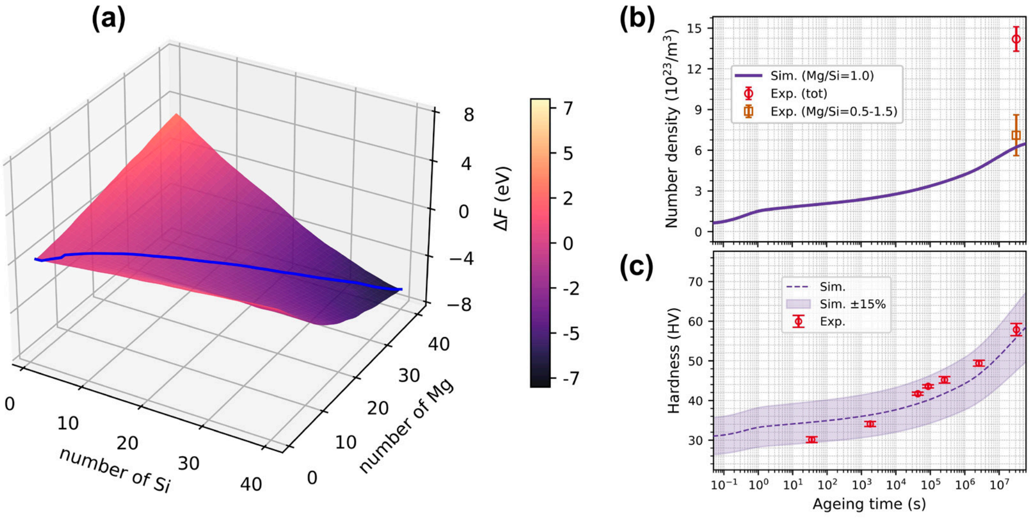


Figure 2. (a) Free energy change for cluster formation as a function of Mg and Si solute numbers at 300 K in an Al-0.46at%Mg-0.95%Si alloy. Time evolutions of (b) cluster number density and (c) alloy hardness during natural ageing after quenching at 400 K/s from 835 K.

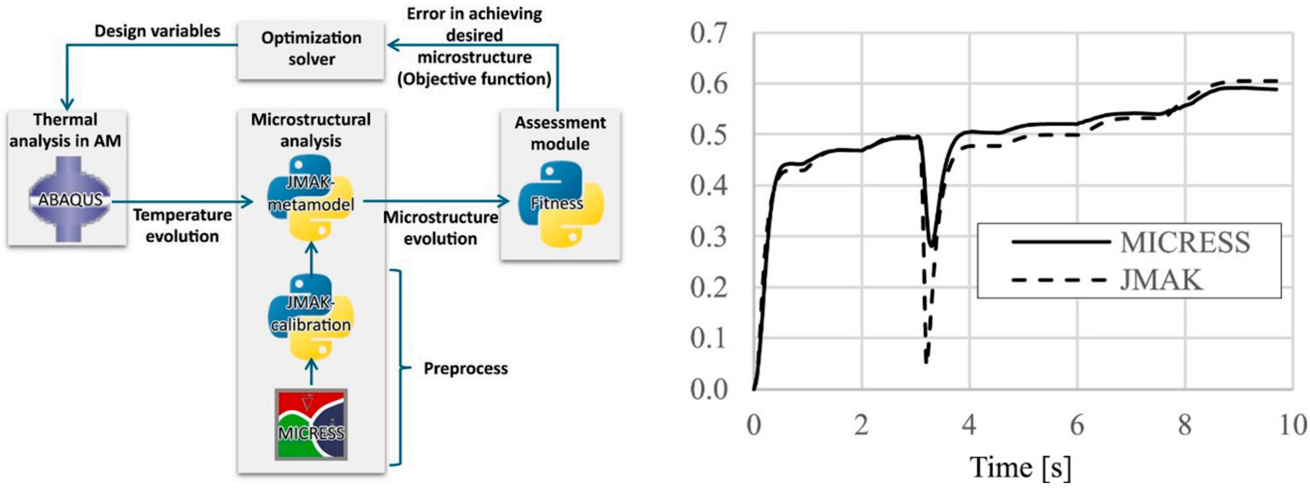


Figure 3. Optimization framework (left) and evolution of the austenite fraction (right) during AM: microscale model (MICRESS) and surrogate model (JMAK)

Modelling of directed energy deposition of duplex stainless steel

It has been investigated how to select the AM process parameters to achieve the desired microstructure without heat treatment. An integral multiscale computational framework for the optimization of the microstructure in metal additive manufacturing was developed (Figure 3). It consists of four modules: (i) the optimization solver that systematically generates feasible designs, (ii) the macroscale module for determining temperature evolution along the deposition process and further cooling, (iii) the microscale module that computes the evolution of microstructure in the deposited part for the temperature histories computed in the previous step, and (iv) the assessment module that quantifies how good the microstructure of the as-deposited part is for each design. The macroscale module uses ABAQUS for the finite element analysis of nonlinear transient heat transfer. The microscale module is a fast metamodel of the multiphase-field model for multicomponent alloys from the microstructure simulation software MICRESS. This metamodel is based on the Johnson–Mehl–Avrami–Kolmogorov law for isothermal transformations, calibrated using MICRESS' results, and extended to non-isothermal transformations by approximating them as a series of isothermal steps. The whole workflow is implemented into ISIGHT, a user-friendly software that provides a suite of visual tools to create simulation process flows. The laser directed energy deposition of duplex stainless steels, whose mechanical properties are highly dependent on the ferrite–austenite ratio, is taken as case study. Results show that the microstructure of the as-deposited part can be significantly improved.

Through-Scale Modeling of Aluminum Alloy Processing and Application of Machine Learning

During this reporting period, a microstructure simulation code for aluminum alloys was successfully ported from a stand-alone PC Windows environment to a Linux high-performance computing (HPC) cluster. The code predicts microstructural evolution during heat treatment, including precipitation kinetics and their impact on material properties. In precipitation-hardenable systems (e.g. 6xxx or 7xxx series), nanoscale precipitates formed during aging strongly control yield strength, making accurate time–temperature modeling essential for alloy and process optimization.

The main objective of this task was to remove a computational bottleneck that previously limited the number of simulations that could be performed. Studies on multicomponent aluminum alloys involve a very large design space, combining variations in alloy chemistry (e.g. Mg, Si, Cu content) with multiple process parameters such as solution treatment temperature, quenching rate, and aging conditions. Running such parametric studies on a local workstation severely restricted throughput and limited systematic exploration.

By deploying the code on the Linux cluster, we enabled large high-throughput simulation workflows. Automated parameter sweeps can now be executed in parallel, thousands of virtual heat-treatment scenarios in a large composition range to be explored within practical time frames. This significantly increased statistical robustness and improved coverage of the compositional and process parameter space.

One key application was the investigation of quench sensitivity. The expanded simulation capacity allowed us to quantify how variations in quenching rate influence precipitation during cooling, and how this in turn affects the final achievable strength after aging. The results provide clearer identification of critical cooling rates and alloy compositions that minimize strength loss due to premature precipitation.

Extrudability of 7xxx alloys with Si addition and torsion tests results

Extrudability trials on simulated recycled aluminum alloys have been performed in other projects outside of SFI Physmet. It was observed that a major increase of Fe in 6xxx does not influence the extrudability, while a slight increase of Si in 7xxx alloys significantly reduce the extrudability. In this task, we worked on the methodology to explain the extrudability observations. We found that equilibrium phase diagram calculations could provide meaningful insights (Figure 4). With equilibrium phase diagram calculation for 6xxx alloys with added Fe, the solidus temperature was found not influenced. On the other hand, Si adding to 7xxx alloys can significantly reduce the solidus temperature. The calculated solidus temperature corresponds well to the extrudability results. The equilibrium phase diagram was also validated by DSC experiments. Hot torsion tests were also performed on 7xxx alloys with different alloying additions, to see the influence of alloying on extrusion force. The calibrated flow stress model gives similar trends to the observed extrusion forces from trials.

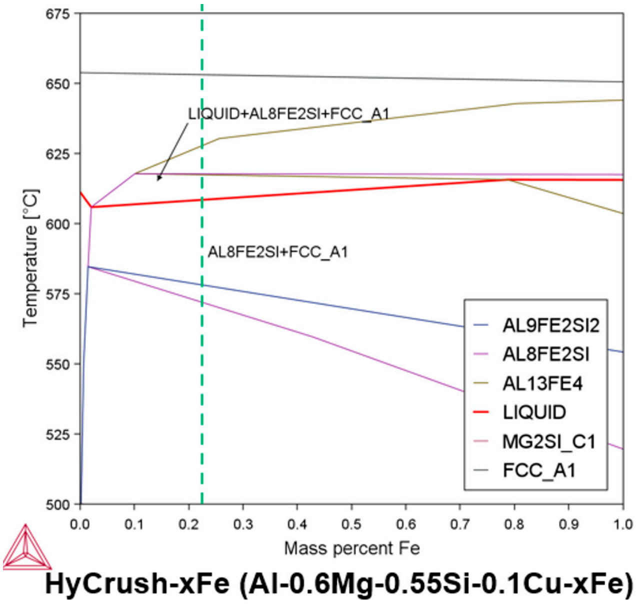


Figure 4. Solidus line for HyCrush alloy with different Fe contents. Fe actually slightly increases the solidus temperature

RESEARCH AREA 3.
SUSTAINABLE AND HIGH-PERFORMANCE MATERIAL DEVELOPMENT

RESEARCH AREA LEADERS:
ASTRID MARTHINSEN
KJERSTIN ELLINGSEN
SINTEF

CONTRIBUTIONS TO CENTRE OBJECTIVES

- The aim of RA3 is to establish fundamental knowledge and understanding of materials with recycled content and/or materials for new processes and applications (e.g. rapid solidification and additive manufacturing).
- To accelerate the design of new materials and alloys and/or industrial processes relationships will be systematized using modelling tools in collaboration with other Research Areas combined with experimental work.

MAIN CHALLENGES TO BE MET

- How to understand the effect of, and compensate for, elevated levels of trace elements from recycled materials and develop robust/novel alloys.
- How to develop and tailor the microstructure of AM/rapid solidification alloys.
- How to recover or improve material properties through post-processing.

ACTIVITIES AND RESULTS IN 2025

In 2025, we had 3 active PhD students working in RA3 (Supreet Kaur, Andreas Voll Bugten and Armel Perrotin), all supervised by professor Marisa Di Sabatino. Additionally, Ali Elashery started as a Researcher in RA3 in 2025. From SINTEF, the core team consists of researcher Astrid Marthinsen, Kjerstin Ellingsen, Kai Zhang and Qiang Du, and from IFE Jinsong Hua is the main contributor. The research activities are organized in four main tasks. A summary of ongoing activities and results from 2025 are shown below.

Solid-state mixing by screw extrusion
Due to a change in priorities of one of the main industry stakeholders, the remaining activities in this task have been put on hold.

Compensation metallurgy and alloy design
Understanding how increased levels of typical aluminium scrap impurities alter alloy microstructure and performance is essential to enable higher aluminium recycling rates. One of the ongoing activities at SINTEF/NTNU is to investigate the effect of increased levels of Fe on the microstructure of an AlSi11MnMg foundry alloy. In 2025, using advanced 3D electron microscopy in collaboration with Research Area 1, we identified a new type of iron-rich intermetallic phase that can form in Al–Si cast alloys and should be limited due to its detrimental plate-shaped morphology (Figure 1) that will be detrimental to mechanical properties. We found that the formation of these particles is highly sensitive to both iron content and

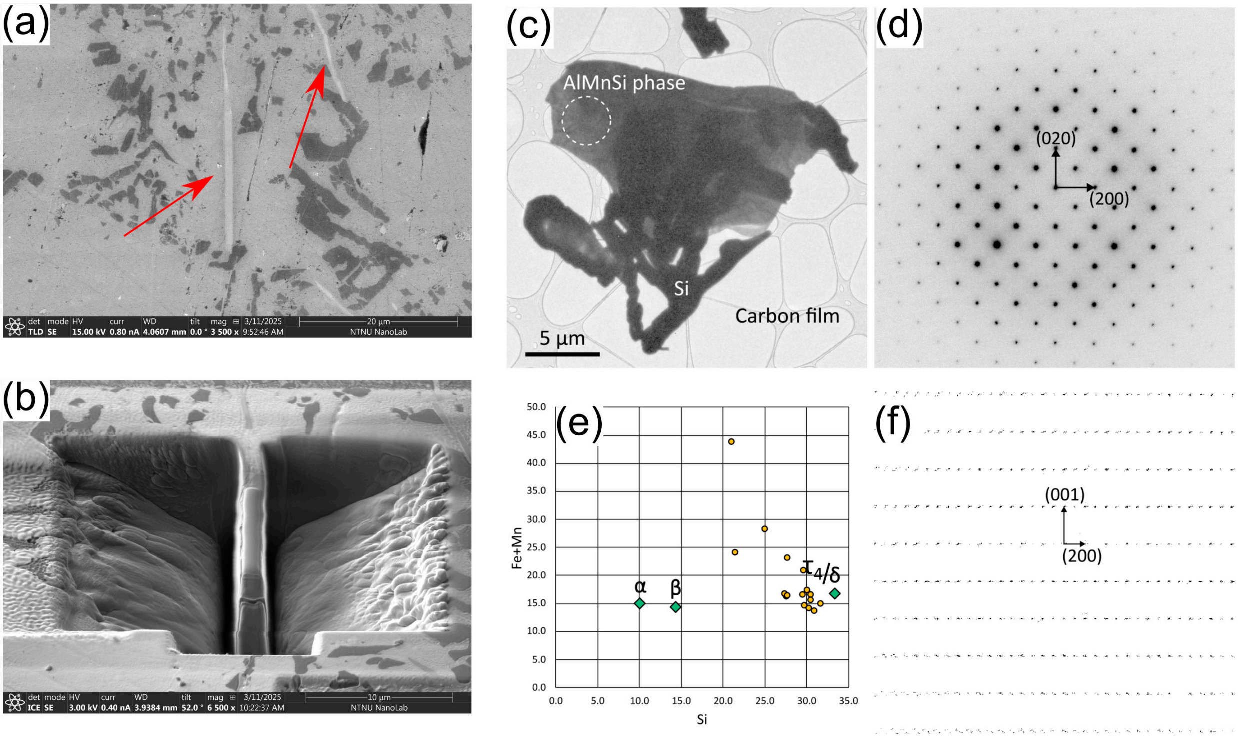


Figure 1 (a) SEM-BSE image of plate-shaped particles. (b) Extraction of plate-particle by Focused Ion Beam (FIB). (c) Low magnification TEM image of a plate-particle covered by Si particles. The circle shows the area that was selected for the diffraction pattern in (d). (e) EDS measurements of 13 particles with identical diffraction pattern to (d), given in atom%. (f) Reciprocal lattice from 3D electron diffraction of the plate phase.

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.

The PhD work of Supreet Kaur focuses on understanding how Fe, Cu and Zn influence the mechanical properties and corrosion resistance of aluminium alloys used for high pressure die casting (HPDC). A central motivation for this research is to enable the automotive industry to safely incorporate higher fractions of postconsumer scrap—where these impurity elements are typically elevated—by identifying the critical microstructure–property relationships that govern alloy performance. Preliminary results from mechanical testing in 2025 indicate that increased levels of Fe have a detrimental effect on the elongation, while electrochemical tests show that Cu has a negative effect on the corrosion resistance. Also, elevated levels of Fe seem to have a detrimental effect on corrosion in samples with high Cu and Zn.

The strength and toughness of cast iron can be attributed to small, typically spherical graphite particles that form during solidification. Modern producers often use recycled steel, but this can introduce trace elements such as boron, which is known to soften cast iron and alter the shape of the graphite. The doctoral research of Andreas Voll Bugten has focused on why this occurs. This work indicates that boron accumulates on the surfaces of graphite as the metal cools. At lower temperatures, this disrupts normal graphite growth, leading to the formation of long, sharp protrusions instead of spherical particles with a smoother surface. These protrusions draw additional carbon from the surrounding iron, leaving the base material carbon-depleted and promoting the formation of softer ferrite rather than pearlite. This mechanism explains the detrimental effects of boron contamination and supports efforts to improve control of impurity levels in cast iron production when scrap metal is used (Figure 3), in collaboration with Elkem.

Powder materials and rapid solidification

In this task SINTEF, NTNU and IFE are developing new aluminium alloys for 3D printing/additive manufacturing (AM) to expand application areas and accelerate the technology's industrial adoption. A key challenge is preventing defect formation during printing. In 2025, through process optimization and adjustment of grain refiner additions, we succeeded in printing crack-free high-strength aluminum alloys—an important step toward broader industrial implementation.

A critical prerequisite for producing crack free components in powder based additive manufacturing (AM) is the quality and consistency of the metal powder. To address this, a new PhD candidate, Armel Perrotin, joined the RA3 team in August 2025. His research focuses on optimising the Al–Si powders produced by Elkem's gas atomizer, with the goal of tailoring powder characteristics—such as particle size distribution, morphology, and impurity control—to meet the requirements of high quality AM components. In 2025, Armel visited Elkem and participated in a gas atomization campaign to produce the first batches of Al–Si powders for systematic investigation. Figure 4 shows a representative scanning electron micrograph of AlSi40 powder from this campaign. In parallel with the experimental activities, IFE have begun developing modelling capabilities for the gas atomization process. This combined experimental–modelling approach will enable us to link processing conditions to powder characteristics and ultimately support the optimisation of Al–Si powders for high quality AM components.

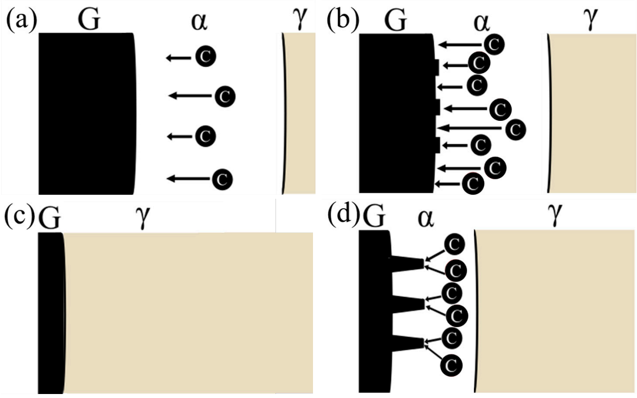


Figure 2. Illustrations showing four different scenarios for diffusion of C. G refers to graphite, a refers to ferrite, γ refers to austenite. (a) A ferritic-pearlitic alloy with no additions of B. The surface of the nodule is smooth, and graphite growth occurs layer by layer by atom attachment on graphite ledges. (b) A ferritic-pearlitic alloy, where B is present. Since the alloy is ferritic-pearlitic, both the spheroidal graphite and graphite protrusions grow during the eutectoid transformation, causing the nodule surface to be rough. Atom attachment occurs on ledges of the spheroidal graphite, and also on protrusions (a-direction facing the matrix). (c) A fully pearlitic alloy without additions of B. No diffusion of C occurs during the eutectoid transformation, meaning no growth of graphite or ferrite occurs, eventually resulting in a fully pearlitic matrix. (d) An alloy designed to be fully pearlitic in absence of B. The presence of B, however, leads to nucleation of graphite protrusions that C atoms can attach to, giving a spiky surface and ferrite growth. Atom attachment occurs preferentially on protrusions (a-direction facing the matrix).

Tailored properties through post-processing

This task targets the deliberate tailoring of microstructures through heat treatments of additively manufactured alloys, aiming to suppress detrimental secondary phases and precipitates while promoting beneficial phase transformations that enhance performance. In 2025, SINTEF have continued to work on advancing thermodynamic descriptions relevant to rapid solidification conditions characteristic of AM processes. These improved models form a foundation for predicting phase stability and transformation pathways with increased accuracy. In parallel, case studies were started on selected aluminium alloys and duplex steels— the latter conducted in collaboration with Equinor.

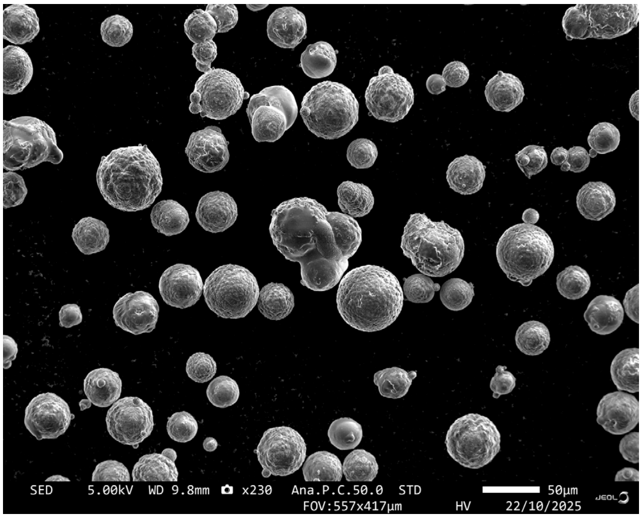


Figure 3 SEM micrograph of atomized AlSi40 powder.

RESEARCH AREA 4.
INNOVATIVE PROCESSING AND JOINING METHODS

RESEARCH AREA LEADER:
MAGNUS ERIKSSON
SINTEF

CONTRIBUTIONS TO CENTRE OBJECTIVES

- Develop knowledge basis for welding of aluminium alloys to achieve full-strength integrity across the weld zone and heat affected zone.
- Develop new high-strength welding wire materials, including nanoparticles, hypereutectic compositions and alloying elements for grain refinement and particle strengthening.
- Develop welding technologies of dissimilar metals (e.g. Al-Cu, Al-Fe, Al-Ti)
- Develop laser welding and Laser-arc hybrid welding for thick steel and aluminium alloys including numerical simulations using CFD approach.
- Develop laser assisted AM- and cladding processes, including new powders (e.g., silicides).
- ..and establish process-microstructure-properties relations and modeling technologies for these processing and joining methods.

MAIN CHALLENGES TO BE MET

- In aluminium welding low weld-metal and HAZ strength remain major challenges. To improve aluminium use in welded structures and AM, new high-strength filler materials and innovative, low-heat welding methods such as laser welding are needed to reduce HAZ softening.
- Dissimilar welding of aluminium to steel, copper, titanium, or other Al alloys can reduce component weight but is hindered by oxide films and brittle intermetallics. Solid-state methods such as friction stir welding (FSW) and hybrid metal extrusion & bonding (HYB) might offer potential benefits.
- Laser-arc hybrid welding of thick steel offers opportunities but also risks. Narrow, deep welds can form hard root microstructures (e.g., lath martensite, retained austenite) and suffer from porosity and cracking. Numerical modelling and in-situ monitoring (e.g., high-speed imaging) help understand and control these defects.
- Directed energy deposition (DED) methods—LMD and WAAM—are increasingly used for repairs, but onsite application is challenging due to variable substrate composition, thickness, geometry, and heat transfer conditions.

ACTIVITIES AND RESULTS IN 2025

In 2025, we had 2(3) active PhD students (Ingvild Runningen, Jan Konkel and Hitesh Kumar (associated; funded by SVV) and one Postdoc, Dr. Jianbin Xu working in RA4. From SINTEF, RA-leader Magnus Eriksson, and researchers Ivan Bunaziv, Asle Tomstad, Aritra Sarkar, Xiaobo Ren, Jørgen Sørhaug and Sir Marthe Arbo, are the main contributors. The research activities in this Research Area are organized into four main research tasks, listed below, together with their main results and highlights.

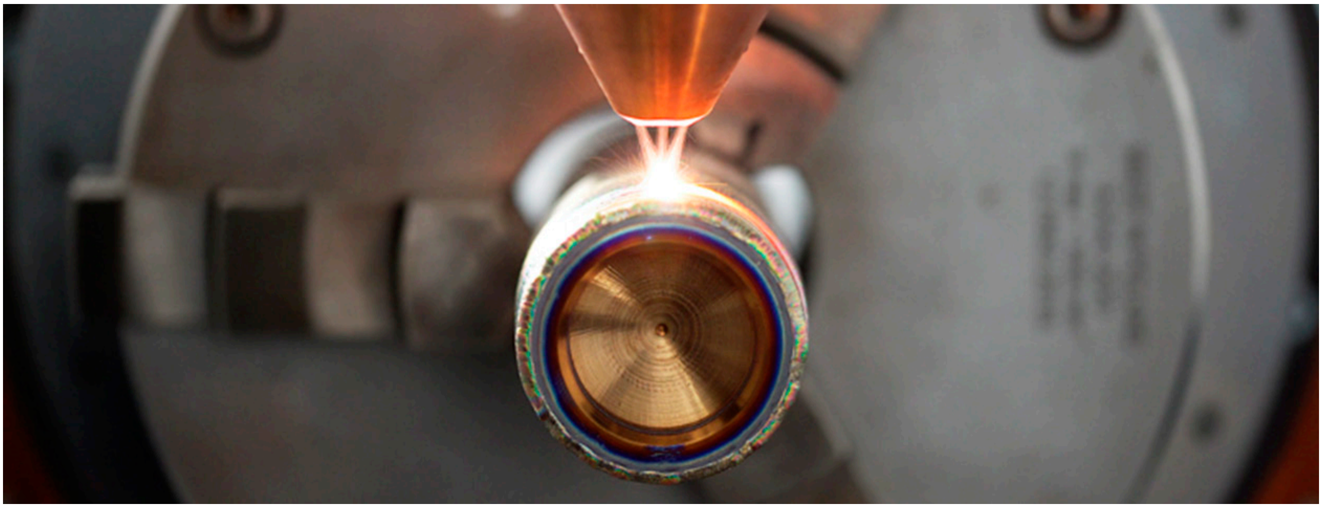


Figure 1 Laser Metal Deposition (LMD) performed at Nordic Additive Manufacturing, Raufoss [Photo: Nordic Additive Manufacturing (NAM)]

Structural Integrity of welded joints of Al-alloys.
This task, redefined in 2025, focuses on the structural integrity of welded aluminium joints. Stakeholders include aluminium producers (Hydro), automotive suppliers (Benteler), and infrastructure developers (SVV). Funding from SVV supports evaluating the fatigue performance of 5083 alloy, widely used in coastal infrastructure for its strength-to-weight ratio and corrosion resistance. Because components such as decks and pedestrian bridges experience cyclic loading, fatigue performance of welded joints must be well understood. Laser welding offers benefits over MIG—lower heat input, reduced distortion, and narrower HAZ—factors that generally improve fatigue life. However, the 5083 alloy is prone to porosity and hot-cracking due to its Mg content, limiting the full advantage of laser welding. Thus, despite favourable HAZ characteristics, defects can significantly reduce fatigue performance.
The task aims to compare fatigue behaviour of laser and MIG-welded 5083, assessing the influence of HAZ width, welding-induced defects (porosity, hot cracking), and microstructure (grain size, intermetallic particles). Fatigue testing and characterization are planned for 2026, along with related Master's thesis projects in collaboration with IMA.

The work in 2025 focused on improving the heat-affected zone (HAZ) properties in welded high-strength aluminium alloys. Measures to reduce HAZ and weld metal softening were explored by adjusting base materials, welding wires, and process technologies. This effort involved extensive student participation: five Master's students and one PhD candidate conducted thesis work related to the task, supervised by NTNU, SINTEF, and Benteler.

PhD candidate **Ingvild Runningen** is finalizing her thesis on incorporating TiC particles into aluminium during casting, studying the effects of salt fluxes and titanium stabilization. Follow up work showed promising TiC particle survivability in TIG welding, and she will defend early 2026. MSc student **Henrik Reberg** delivered a thesis on TiC-reinforced aluminium MMCs produced via molten salt-assisted stir casting, examining microstructural evolution from cast material to welding wire and weld. **Liesbeth Campbell** is working on her MSc thesis on WAAM-produced 5183 aluminium using screw-extruded wires with TiC nanoparticles and studying $TiAl_3$ particle growth, in collaboration with RA1.

MSc student **Henrik Elton** delivered his Master thesis on heat-treatable welding wires from the 6xxx (Al-Mg-Si) - and 7xxx(Al-Zn-Mg(-Cu) series aluminium alloys for joining of 7108 profiles.

Welding of aluminium alloys and dissimilar metals
Solid-state welding technologies such as Friction Stir Welding (FSW) show strong suitability for producing robust multi-material components. Compared to fusion welding, they reduce HAZ width and limit brittle intermetallic formation, resulting in stronger, more ductile, and durable joints. In 2025, efforts focused on producing defect-free buttwelds between aluminium alloys (1370 and 6101 from Hydro) and copper. By optimizing

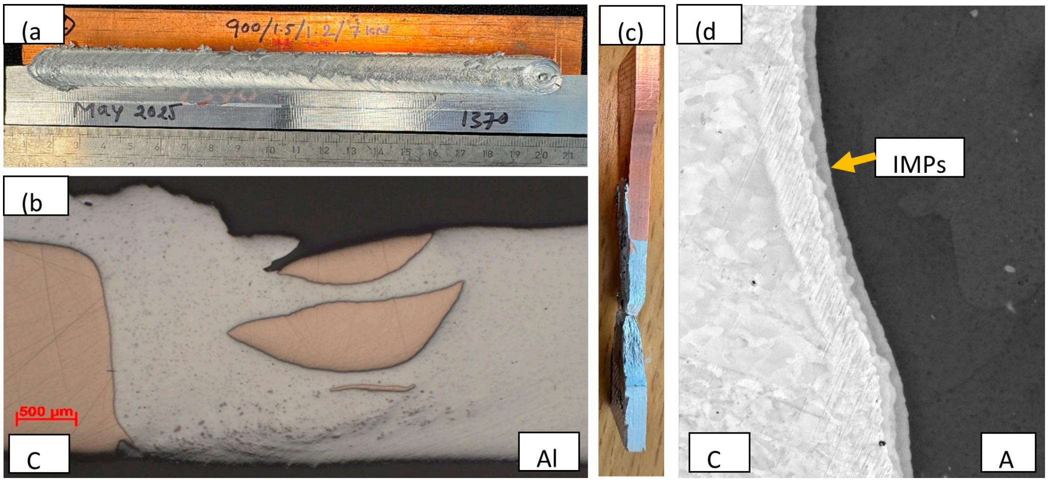


Figure 2: (a) Successfully welded Al (1370 alloy) and pure Cu using the new FSW machine installed at Sintef Industri in Raufoss. (b) Optical image of an Al-Cu weld cross-section. (c) Fractured Al-Cu weld tensile test specimen. (d) High-resolution SEM image showing a thin layer (0.5 μm) of brittle Al-Cu intermetallic phases (IMPs).

tool design and process parameters, high-quality joints with an extremely thin Al–Cu intermetallic layer were achieved (Figure2). Tensile tests showed fractures consistently outside the stir zone rather than at the interface, confirming strong bimetallic joints. These results highlight Al–Cu FSW as a promising solution for lightweight components needing good electrical or thermal conductivity, such as busbars and power distribution parts. Long-length Al–Cu welds were also demonstrated, confirming industrial readiness. The validated process will next be applied to aluminium-to-steel buttwelding, directly addressing broader multi-material joining challenges.

Laser-arc hybrid welding of thick steel and aluminium alloys

Deep penetration laser arc hybrid welding (LAHW) offers major productivity gains due to its low heat input, which reduces distortion and residual stresses compared to traditional arc welding. However, for steels the high depth-to-width ratio also increases the risk of defects and formation of brittle phases in the weld and HAZ. Despite these challenges, economic evaluations show LAHW can deliver substantial efficiency and cost savings with comparable mechanical performance, making it a promising technology for thick-section steel in offshore and bridgebuilding applications. A review paper summarising these developments was published in 2025.

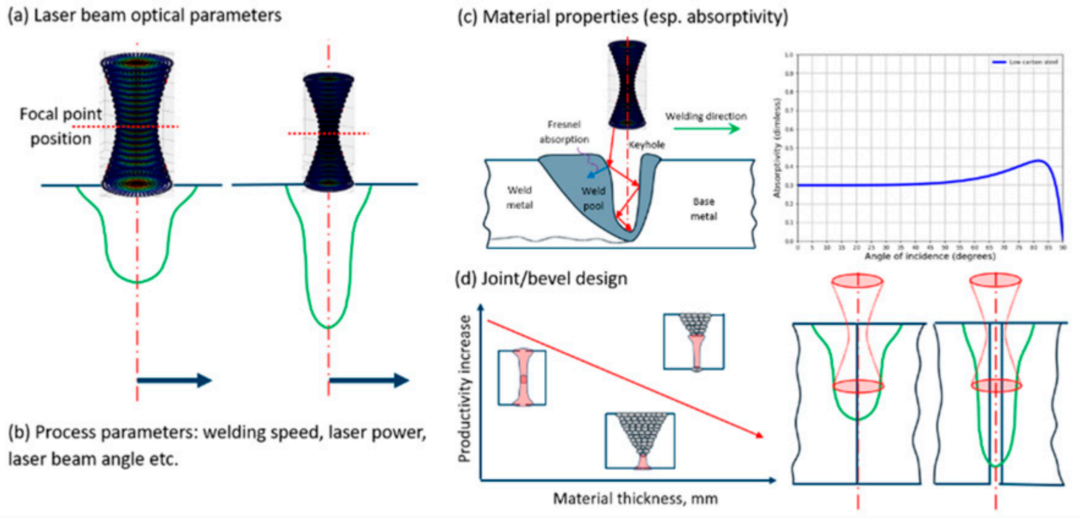


Figure 3. The factors which influence penetration depths in laser-based welding and its design for thick steel section joining.

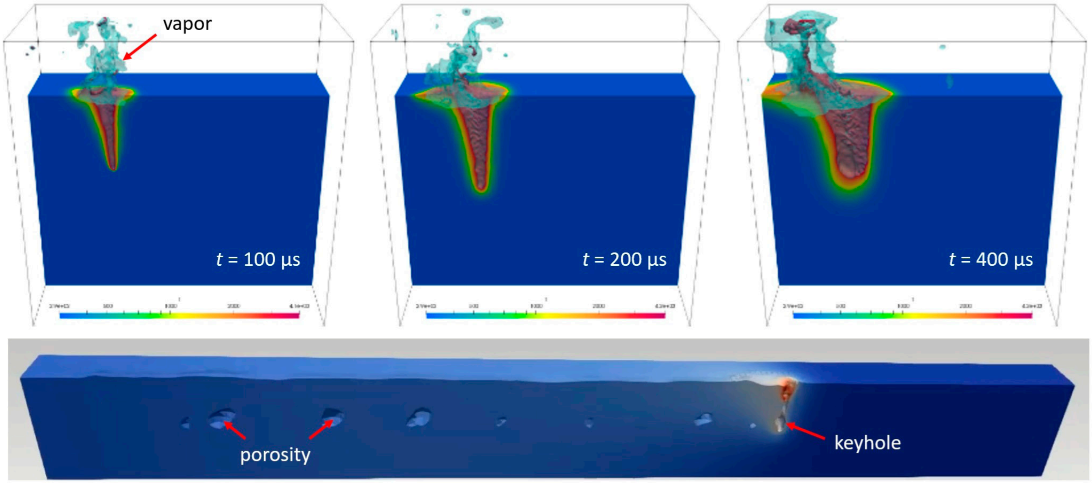


Figure 4 Numerical modelling of (a) laser beam keyhole welding with vapor phase and (b) laser beam welding of aluminium 6082 alloy plate with advanced adaptive mesh refinement.

Low-transformation temperature (LTT) alloys are sometimes used in welding to reduce residual tensile stresses and distortion, improving mechanical properties, fatigue performance, and service life. From 2023 to 2025, hybrid welding of thick structural steels was a high-priority research area. Vacuum laser experiments on 40mm S460ML and S690QL steels were conducted in Germany, and several low-transformation temperature (LTT) filler shims were evaluated. Austenitic 309LMo shims provided excellent toughness at –30 °C, while special-grade LTT shims performed poorly due to martensitic microstructures caused by excessive dilution. Surprisingly, autogenous LBW also showed high toughness, likely due to tempered bainite and low residual stress. Producing single-pass welds in such thick sections remains challenging and requires extremely high precision. In 2025, two MSc projects successfully demonstrated that nano and microparticles (TiO_2 and TiN) can promote acicular ferrite formation under ultrafast cooling and refine prior austenite grains.

Numerical modelling is becoming increasingly important for thick-plate laser welding. In 2025, SINTEF contributed to the development of Laser BeamFoam-solver in OpenFOAM, resulting in a joint publication with the University of Manchester and University College Dublin. The upgraded solver now includes advanced compressible models, however it remains computationally demanding and requires expert setup. Future work will use these solvers to simulate defects such as humping and internal flaws, calibrated against experimental data.

Results on LTT Alloys in Laser Directed Energy Deposition and Cladding

In the Norwegian offshore sector, Low Temperature Transformation (LTT) alloys are increasingly attractive for repair and cladding applications due to their favourable metallurgical behaviour.
Laser-based directed energy deposition (DED) offers a flexible platform for such repairs, but systematic studies on LTT alloy processability under DED conditions remain limited. The repeated thermal cycles during deposition complicate martensitic transformation and produce complex residual stress fields. To address this, PhD student **Jan Konkel** investigated the processability and microstructural evolution of LTT alloys fabricated by laser DED. This work compared two commercial powders and an experimental powder produced from OCTG pipes, each with different martensite start/finish temperatures. Single and double-bead deposits were printed on OCTG substrates while varying laser energy, scan speed, powder feed rate, and hatch distance. The deposits were then analysed for bonding quality, porosity, hardness distribution, and microstructure. Results will be presented at the IIW Annual Assembly 2026 in Salzburg.
Structures exposed to the marine atmosphere, i.e., seawater, are expected to corrode severely due to the corrosive conditions that are particularly severe within the splash zone. Cladding with corrosion-resistant alloy can prevent periodic maintenance required over the years and save huge cost. PhD student **Hitesh Kumar** funded by SVV (National Road Administration) has been studying the dilution of iron (Fe) in laser cladding of Alloy-625 superalloys and found that dilution increases with increased laser power. However, higher wire feed rates, increased travel speed, and reduced defocusing distances tend to decrease dilution.

RESEARCH AREA 5.
DATA, SHARING AND DIGITAL PLATFORMS

RESEARCH AREA LEADER:
JESPER FRIIS
SINTEF

CONTRIBUTIONS TO CENTRE OBJECTIVES

- Make research results (data and modelling tools) accessible and easy to combine and reuse.
- Enabling both industry and research partners to make efficiently use of the project results promoting rapid innovation.

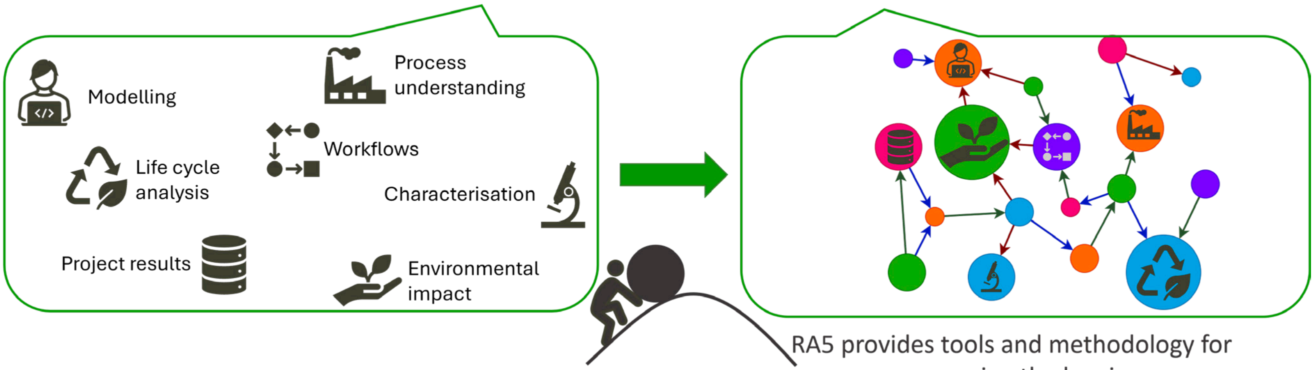
MAIN CHALLENGES TO BE MET

- How to share models and data produced within the centre.
  Strategy: create a web portal for physical metallurgy where the models and data can be shared.
- How to represent scientific results and knowledge within physical metallurgy such that they become FAIR (findable, accessible, interoperable and reusable) as well as traceable and actionable (allow action based on insight).
  Strategy: build a knowledge base for physical metallurgy using common standards and physics-based ontologies to describe the knowledge.
- A key challenge is to at one hand include enough details about the data to address the above points while at the other hand making the documentation process practical and simple enough that it will be realized.
  Strategy: develop new schemes for data documentation with a web interface to supporting tools.
- How to exploit the platform for increased quality and productivity in research and industrial innovation?
  Strategy: involvement of stakeholders and early demonstrations.

To tackle these main challenges, the work in this Research Area is organised into three research tasks: platform design, platform implementation and platform exploitation.

The effort is strengthened by close collaboration with key international players within the network surrounding the European Materials Modelling Council and reuse of experience and state-of-art technology developed in collaborative European projects.

Creating a PhysMet knowledge base
Figure 1 illustrates an important aim of RA5, to support the transition from data and domain knowledge residing in isolated silos to an integrated knowledge base. This will be done by providing needed methodology and tools for (i) populating the knowledge base with results from the centre and (ii) accessing the knowledge base and thereby making the results of the centre truly FAIR. The strategy is to start with a few selected use cases and slowly expand.



RA5 provides tools and methodology for overcoming the barrier

Figure 1. RA5 aims to support the transition from data and domain knowledge residing in isolated silos to an integrated knowledge base by providing the methodology and tools for overcoming the transition barrier.

Platform design
This task focuses on the design of a digital platform for the centre that will allow to document and seamlessly connect results from advanced characterisation, experimental testing, data processing and modelling from electronic to continuum scale. Surrounding projects and other target users will also be invited, to ensure that the platform will expand after the end of the SFI and serve as a national digital hub for innovation and collaboration within physical metallurgy. An important part of this task is to create a domain ontology for metals and alloys, focusing on the needs from RA1-RA4.

Platform implementation
The implementation of the platform is using core technology from various EU projects and tailored to the user needs expressed in task 5.1. It will combine existing and new components: i) database management and associated search and visualization tools, ii) interoperability modules to apply seamlessly various numerical models, iii) secured and user-friendly web interface.

Platform exploitation
This task focused on exploiting both the data and available models to produce new analysis and support innovation. This task will involve workflow demonstrators, development of application specific interfaces for data analysis, as well as training and frequent user meetings to encourage the active use of the platform in all RAs.

ACTIVITIES AND RESULTS IN 2026

Workshop on Data Documentation
A dedicated workshop on data documentation was organized for PhD candidates and researchers across the centre, hosted with hybrid participation. The hands-on session addressed key RA5 objectives related to making research outputs FAIR (findable, accessible, interoperable, and reusable) and traceable, by training participants to structure, document, and store their own experimental and modelling data using suggested guidelines. By requiring attendees to bring own datasets, the workshop involved gathering user feedback on documentation needs and usability constraints. The event strengthened awareness of best practices for data management across RA1–RA4, promoted a culture of systematic documentation essential for future data sharing through the planned web portal for physical metallurgy.

Documenting characterisation and modelling workflows
The representation of workflows in the knowledge base is based on a simple pattern consisting of a process step with its input and output objects as shown in Figure 2. By combining this simple pattern in different ways, arbitrary complex workflows can be constructed.

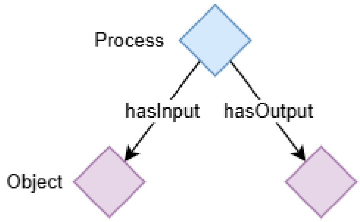


Figure 2. Basic pattern for describing a workflow.

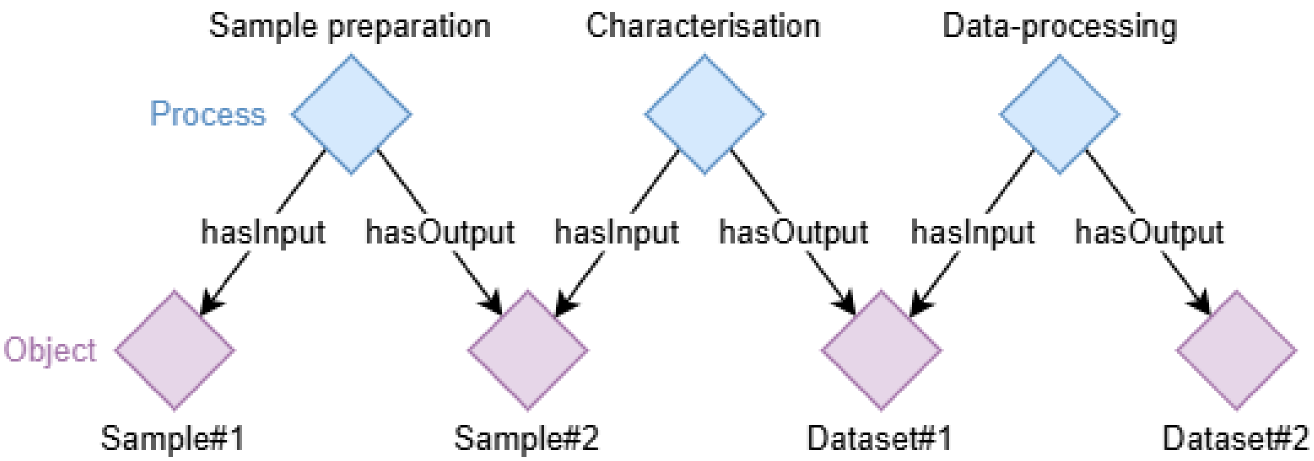


Figure 3. A schematic example of a simple linear characterisation workflow consisting of three process steps, where the output of the first process step is the input to the next, and so forth.

Figure 3 shows a little more elaborated example that combines three processing steps, (i) preparation of a sample (sample#1), (i) characterisation of the prepared sample (sample#2) which results in a dataset (dataset#1) and (iii) postprocessing of the dataset, which results in a new dataset (dataset#2). In the knowledge base it is possible to add more context, like that sample#1 and sample#2 are two temporal parts of the same material.

By looking at Figure 3, one may notice the graph structure of the knowledge base, where each node is connected by a directed relation. This is a very versatile and expressive way to express knowledge. It opens for logical reasoning and efficient harvesting by AI tools. The above-described methodology was in 2025 applied to document the TEM characterisation workflow of Inga Konow in RA1 illustrated in Figure 4.

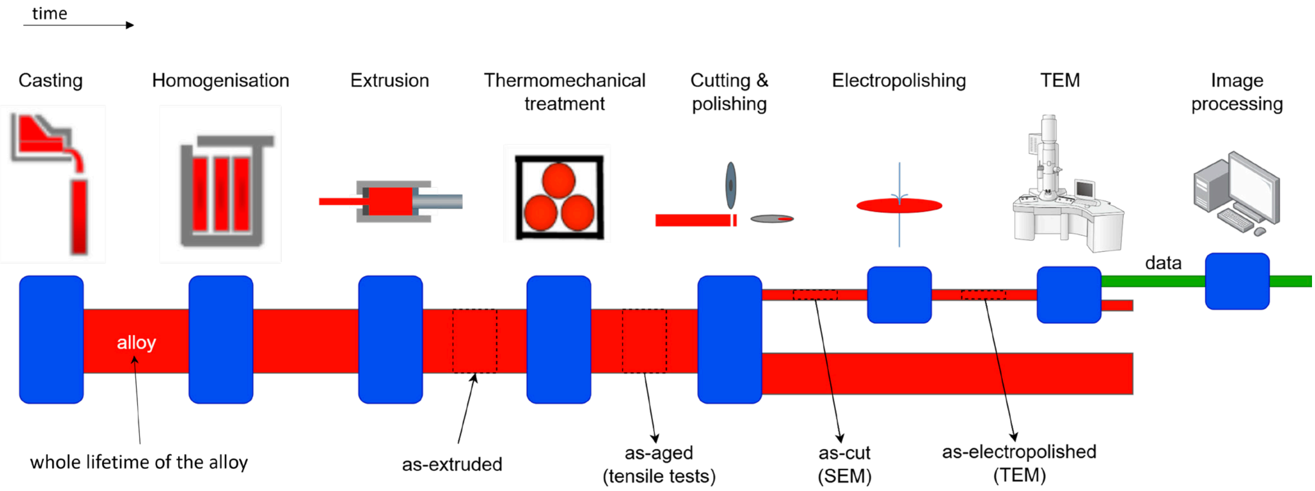


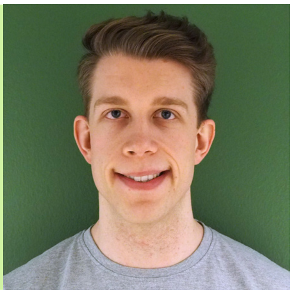
Figure 4. Illustration of the TEM characterisation workflow by Inga Konow.

OUR PHD CANDIDATES

During the eight years Centre period we will recruit and educate numerous PhD candidates, Postdoctors and master students. We are looking for competent and motivated candidates in all of the Centre's research areas.

Nine talented PhD candidates have been recruited to SFI PhysMet, and three more started in 2025. We are looking forward to following their scientific progress in the years to come! Here is a short presentation of our PhD candidates.

PHD CANDIDATE
ANDREAS VOLL BUGTEN (2021-2025)



Research topic: The effect of trace elements on the microstructure development and mechanical properties of cast irons.

Supervisor: Prof. Marisa Di Sabatino

PHD CANDIDATE
XUEZHOU WANG (2021-2025)

Research topic: Develop precipitation model with improved nucleation concepts, addressing the influence of impurity elements, vacancy and atom clustering kinetics.

Supervisor: Prof. Yanjun Li

PHD CANDIDATE
INGVILD RUNNINGEN (2021-2025)

Research topic: Development of nanoparticle-containing aluminum filler wires

Supervisor: Prof. Ida Westermann

PHD CANDIDATE
MAGNUS REIERSEN (2021-2025)

Research topic: Material development and microstructure control for powder based additive manufacturing processes

Supervisor: Assoc. Prof. Tomas Manik

Funded by SINTEF

PHD CANDIDATE
HÅKON LONGVA KORSVOLD (2023-2026)

Research topic: Advanced nanoscale characterization of grain boundary segregation in metals.

Supervisor: Prof. Yanjun Li

PHD CANDIDATE
INGA DAHLEN KONOW (2024-2027)

Research topic: The effect of deformation on 6xxx Al-alloys

Supervisor: Randi Holmestad

PHD CANDIDATE
SUPREET KAUR (2023-2026)

Research topic: The effect of trace elements on recycled Al Alloys

Supervisor: Prof. Marisa Di Sabatino

POSTDOC
JIANBIN XU (2024-2026)

Research topic: Laser-based welding of steel and aluminium alloys

Supervisor: Knut Marthinsen, Magnus Eriksson

PHD CANDIDATE
JAN KONKEL (2024-2027)

Research topic: Development of Low Transformation Temperature (LTT) Steel Alloys for Welding and Additive Manufacturing Applications

Supervisor: Tomas Manik

PHD CANDIDATE
HITESH KUMAR (2024-2027)

Research topic: The Corrosion protection of floating structures using laser welding technology

Supervisor: Nima Razavi

NEW PHD AND POSTDOC CANDIDATES IN 2025

Three new PhD candidates and two new Postdoc started in 2025. We have asked the new PhD and Postdoc candidates to give a short description of their projects and the expected impact for industry.

PHD CANDIDATE

THYRA ROLFSENG

(2025-2028)

Topic: In-situ TEM investigations of precipitates in Al-Zn-Mg-(Cu) alloys

Supervisor: Randi Holmestad

Background: Master's degree in Nanotechnology from NTNU. Topic: *"Strain and magnetic domain analysis of gallium ion-induced nanomagnets using SPED and LM-STEM-DPC".*

The PhD project: This PhD project aims to investigate the phase transition from solute clusters to precipitates in 7xxx series aluminium alloys using in-situ TEM.

Methods: The application of in-situ TEM will enable real-time observation and quantification of precipitate evolution in Al-Zn-Mg-(Cu) aluminium alloys. Sample preparation will be conducted using FIB, ensuring site-specific lamellae suitable for dynamic TEM studies.

Expected impact for industry: The Al-Zn-Mg-(Cu) alloys are widely used in applications demanding high mechanical strength, such as the aerospace sector. This project will contribute to a deeper understanding of precipitation mechanisms in these alloys and support the optimization of mechanical performance by tuning the elemental composition and thermomechanical treatment.

PHD CANDIDATE

ARMEL PERROTIN

(2025-2028)

Topic: Engineering of Aluminium-Silicides alloys for additive manufacturing applications

Supervisor: Marisa Di Sabatino

Background: Master's degree in Green Chemistry, Catalysis and Environment from Université de Poitiers (France). Topic: *Catalyst preparation and characterization for Ozone and Volatile Organic Compounds (VOC) removal for aircraft air purification.*

The PhD project: Improve the understanding of the process and material parameters that make a powdered aluminium-silicium alloy suitable for additive manufacturing (AM) applications.

Methods: The main characterization techniques used for this work will be scanning electron microscopy (SEM) for the particles microstructure, as well as chemical analysis like glow discharge mass spectrometry (GD-MS) and Fourier transform infrared spectroscopy (FT-IR).

Expected impact for industry: Additive manufacturing of aluminium-silicides has huge potential for scale up on an industrial level but lacks understanding on which alloy composition would produce the best parts for a wide range of applications.

PHD CANDIDATE

WILLIAM FRØNNING THYHOLDT

(2025-2029)

Topic: Through-Process Modelling of Aluminium Alloys

Supervisor: Bjørn Holmedal

Background: Master's degree in Chemical Engineering and Biotechnology from NTNU. Topic: *Electrowinning of Fly Ash Leachate*.

The PhD project: Developing a deeper understanding of the mechanisms of recrystallization specifically during processing.

Methods: Both modeling and lab work will be performed. Models can be developed using machine learning or finite element methods. In the lab the models can be tested using the Gleeble machine, mechanical tests and SEM.

Expected impact for industry: A better understanding of microstructure mechanics during processing of aluminium alloys can help industries design new materials and production pathways. This could lead to better tailoring of material properties or more efficient production.

RESEARCHER

EMRE ÇINKILIÇ

(2025-2027)

Topic: Multi-scale and Through Process Modeling of Al Alloys

Supervisor: Bjørn Holmedal, Tomas Manik, Knut Marthinsen

Background: PhD degree in metallurgy from The Ohio State University. Topic: Alloy Design and Precipitation Modeling of High Fe Concentration Recycled Cast Aluminum Alloys for Structural Applications.

The PhD project: This project develops integrated multi-scale and through-process models to predict the evolution of microstructure and mechanical properties in Al alloys. The work links thermodynamics, solidification, heat treatment, and deformation behavior within a unified digital framework to improve alloy performance and process efficiency.

Methods: CALPHAD-based thermodynamic calculations, physics-based models, and finite element process simulations are combined with data-driven and machine learning approaches to accelerate optimization and improve predictive accuracy.

Expected impact for industry: The project aims to enable faster alloy qualification, reduced experimental costs, improved impurity tolerance in recycled Al, and enhanced process control. It will support digitalization and sustainable manufacturing in casting, extrusion, and forging industries.

RESEARCHER

ALI ELASHERY

(2025-2027)

Topic: Laser-based welding of steel and aluminium alloys

Supervisor: Knut Marthinsen

Background: PhD in Physical Metallurgy (University of Quebec, Canada, 2022): hot deformation and recrystallization of extruded 6xxx Al alloys with Zr additions. Postdoctoral work also includes HPDC of thin-walled Al–Si alloys for gigacasting applications.

The Postdoc project: Microstructural characterization of recycled aluminium alloys processed by extrusion, HPDC, and additive manufacturing (AM). The aim is to determine impurity tolerance and its effect on microstructure evolution and mechanical properties, considering key process parameters for each route.

Methods: Microstructure characterization from LOM to SEM (EBSD/EDS) and XRD, with high-resolution analysis by TEM and APT. Mechanical response is assessed using tensile testing and hardness.

Expected impact for industry: Improved guidelines for using recycled aluminium by defining impurity tolerance limits across processes. This supports more reliable properties, less rework, and faster alloy/process selection in industrial manufacturing.

PHDS EDUCATED IN THE SFI PHYSMET ENVIROMENT IN 2025

Dr. Andreas Voll Bugten defended his PhD thesis, *"The influence of boron on spheroidal graphite cast iron microstructure,"* on December 18, 2025. His trial lecture focused on "Quality Control in Steel Recycling: Managing Impurities and Tramp Elements." The research was conducted at the Department of Materials Science and Engineering at NTNU, supervised by Professor Marisa Di Sabatino with co-supervision from Professor Yanjun Li, Dr. Leander Michels, and Emeritus Professor Lars Arnberg.

The assessment committee consisted of Emeritus Professor Jacques Lacaze (University of Toulouse), Professor Babette Tonn (TU Clausthal), and Professor Knut Marthinsen (administrator).

Bugten's PhD examined how boron, introduced through recycled steel, affects cast iron. Even very small amounts of boron were shown to soften the material and disrupt the normally spherical graphite particles by accumulating at their surfaces, forming sharp protrusions and increasing carbon depletion from the iron. His findings significantly improve understanding of these mechanisms and support the development of strategies for controlling impurities in scrap-based cast iron production.

The project was fully funded by SFI PhysMet in close collaboration with Elkem. Bugten is the first PhD candidate entirely funded by the SFI, marking an important milestone for the center.

From left: Knut Marthinsen, Prof. Babette Tonn, Prof. Jacques Lacaze, PhD Andreas Bugten and Marisa Di Sabatino (Photo: Emmanuelle Ott).

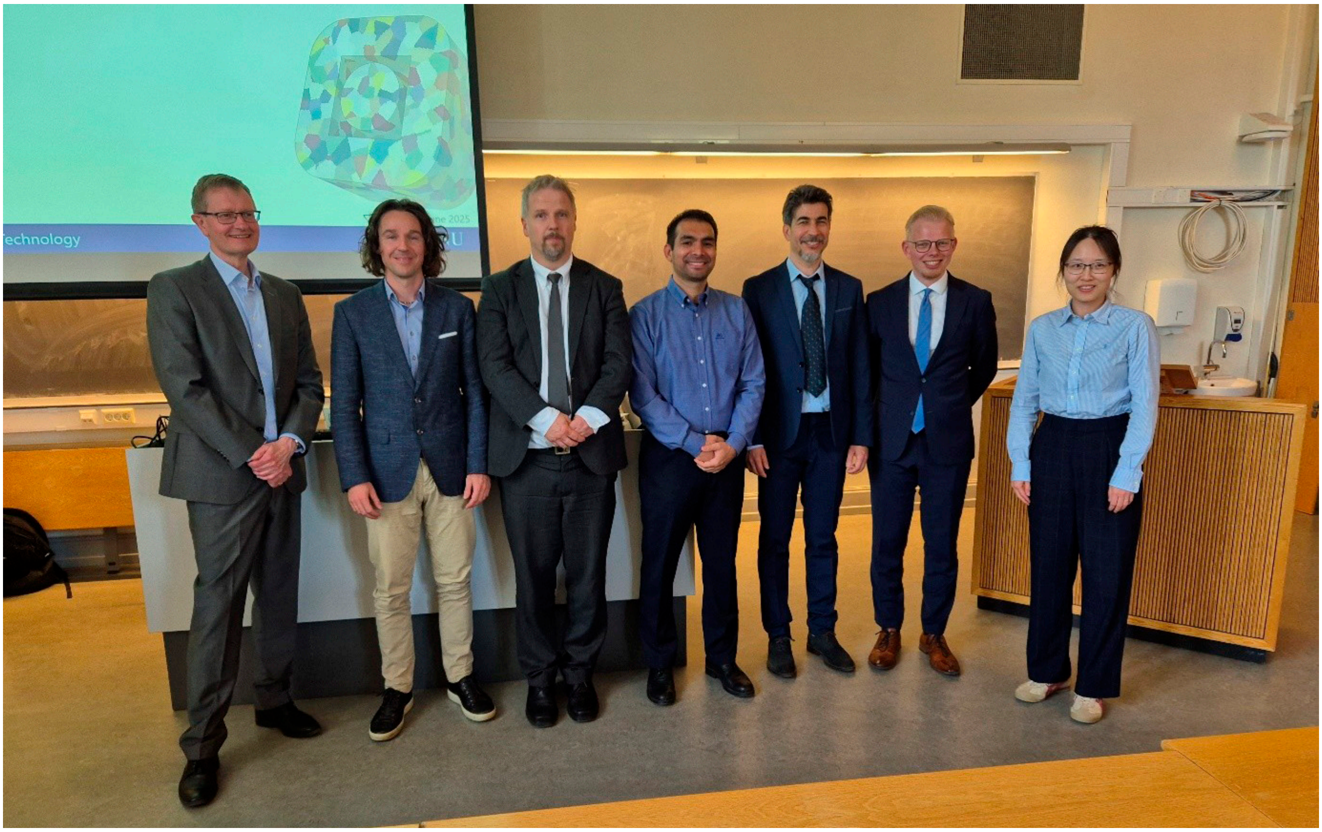
The PhD candidate, Chunan Li, with his supervisors and PhD defense opponents. From left, Assoc. Prof. Xu Lu, Prof. Randi Holmestad, Dr. Jostein Røyset, Chunan Li, Prof. Yanjun Li and Dr. Calin Marioara. Prof. Alexis Deschamps can be seen on the screen above. (Photo: Knut Marthinsen).

Dr. Chunan Li defended his PhD thesis, *"Solute clustering and early-stage precipitation in Al Mg Si alloys,"* on September 26, 2025. His trial lecture covered *"Development of High-Strength and Heat-Resistant Aluminium Alloys Based on Additive Manufacturing."* The research was conducted at NTNU's Department of Materials Science and Engineering under the supervision of Professor Yanjun Li, with co-supervision from Senior Researcher Calin Daniel Marioara (SINTEF) and Professor Randi Holmestad.

The assessment committee included Professor Alexis Deschamps (first opponent, online), Dr. Jostein Røyset (second opponent), and Associate Professor Xu Lu (administrator). The PhD project was funded by the NFR KPN project SumAl, which focused on solute clustering and early precipitation in Al Mg Si alloys, closely aligned with the aims of SFI PhysMet.

Dr. Li combined TEM, atom probe tomography, and atomistic modeling to study how solute clusters form and transform into hardening precipitates. His work demonstrates that carefully controlled heat treatments, particularly a short pre aging step, promote beneficial clusters while suppressing detrimental ones. This leads to aluminium alloys with improved strength and ductility, offering significant potential for lighter and safer components.

His thesis includes four journal papers, two already published. Dr. Li's research provides new pathways for designing high performance aluminium alloys.



Dr. Hassan Moradi Asadkandi (in the middle) together with his supervisors and the Evaluation committee: From left: Prof. Odd Sture Hopperstad, Associate Professor Tomas Manik, Professor Bjørn Holmedal, Dr. Hassan Moradi Asadkandi, Assistant Professor E. S. Perdahcioglu, Univ. of Twente, Assistant professor Knut Andreas Meyer, Chalmers, and Assistant Professor Xu Lu, NTNU (administrator of the committee).

Dr. Hassan Moradi Asadkandi defended his PhD thesis, *"Anisotropy of Polycrystalline Metals and Lattice Structures: An Open-Source Crystal Plasticity Framework,"* on June 6, 2025. The research was conducted at NTNU's Department of Materials Science and Engineering under the supervision of Professor Bjørn Holmedal, with co-supervision from Associate Professor Tomas Manik, Professor Odd Sture Hopperstad, and Research Scientist Baptiste Reyne.

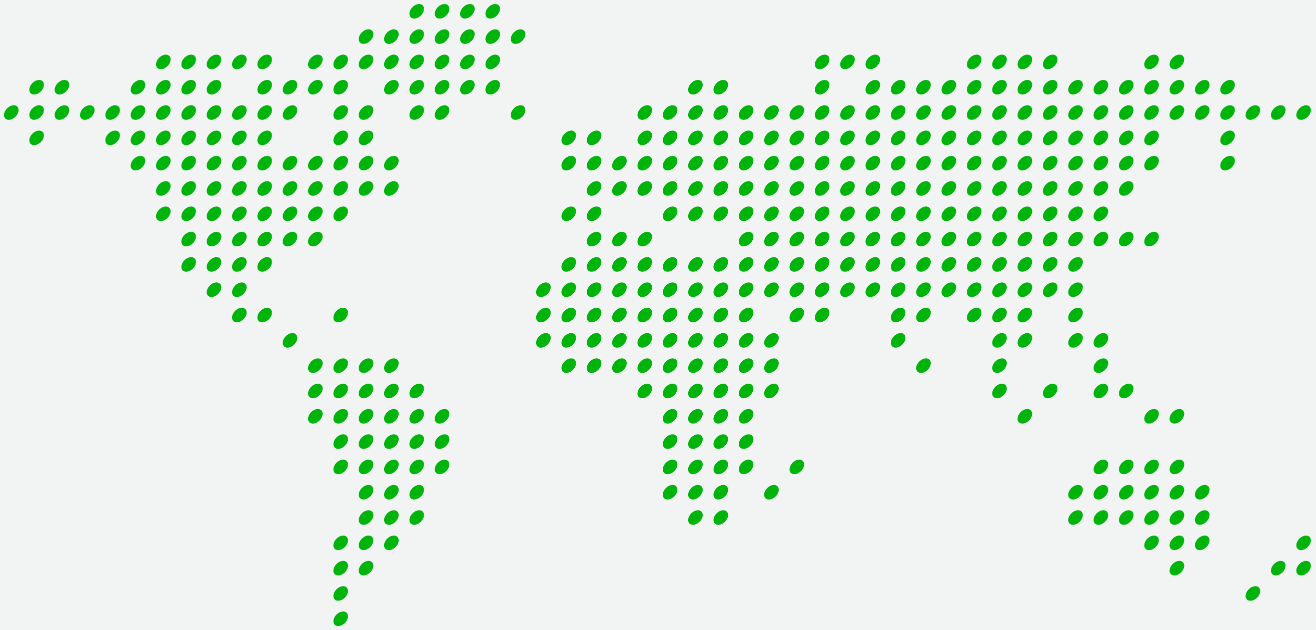
The project was funded by the NFR FriPro project MetPlast, and although not funded through SFI PhysMet, Dr. Asadkandi worked closely with the SFI community, and his results are highly relevant to future research in RA2 on metal forming.

His PhD work focused on advancing the modelling of plastic deformation in metals by linking microstructural mechanisms to macroscopic behaviour using the Crystal Plasticity Finite Element Method (CPFEM). Key contributions include:

- Developing and benchmarking efficient implicit and explicit CPFEM implementations in Abaqus, with improvements such as adaptive substepping and line search stabilization.
- Creating tools to enable CPFEM simulations of complex geometries, including micro components and additively manufactured lattice structures, and providing a Python tool for generating polycrystalline models to study texture effects.
- Establishing a framework for analyzing elasto plastic transitions and plastic flow under strain path changes, including studies of yield surface evolution and vertex formation.

All implementations are open-source, enhancing accessibility and promoting reproducible research within the materials science and engineering community.

INTERNATIONAL COLLABORATION



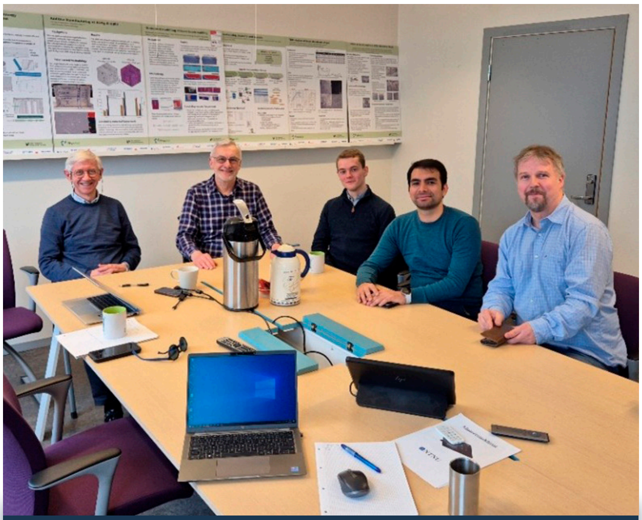
SFI PhysMet has an extensive international network, and several of our professional environments are highly internationally recognized in their fields. The researchers in and around SFI PhysMet are generally very active with regard to publication in internationally recognized journals, and many of the researchers regularly give invited presentations (keynote/plenary lectures) at major international scientific conferences in our fields.

Participation and visibility at international conferences is also an important way to keep up with state-of-the-art scientific knowledge and trends on relevant topics for SFI PhysMet and bring this back to our colleagues and industry partners.

Below is a selection of some activities in this context presented.

Visit of Emeritus Professor Frederic Barlat, POTECH, South Korea and Univ. of South Brittany, France

In March/April, SFI PhysMet co-hosted an extended visit by Emeritus Professor Frederic Barlat, POTECH, South Korea and Univ. of South Brittany, France. Prof. Barlat has experience from both industry and academia in several countries (incl. USA, Korea and France) and has for decades been a leading expert in metal processing and forming, both for aluminium and steel.



Scientific discussion at the SFI PhysMet premises. From left: Knut Marthinsen, Frederic Barlat, Daniel Eckhoff, Hassan M Asadkandi, Bjørn Holmedal (Photo B. Reyne).

The visit to NTNU/SINTEF was co-hosted by the GEMINI centres, Physical Metallurgy and Metal forming, FRIPRO Metplast, as well as SFI PhysMet. During his stay at NTNU/SINTEF he had scientific discussions with NTNU professors, PhD candidates and postdocs as well as SINTEF researchers. As part of the SFI PhysMet webinar series Professor Barlat gave a guest lecture with the title 'Distortional plasticity and application'. Friday April 4th a full day seminar was organised with a presentation from Prof. Barlat on 'Continuum thermodynamics of plasticity' as well as with contributions from both NTNU experts (from Department of Materials Science and Engineering, Department of Structural Engineering and Department of Mechanical and Industrial Engineering) and from SINTEF Industry.

The Trondheim International Summer School on Aluminium Alloy Technology (ISSAAT), 2025

The Trondheim International Summer School on Aluminium Alloy Technology - NTNU (ISSAAT) was organized at NTNU 16th-20th June 2025. The school had 43 participants and 18 lecturers from 9 different countries (Norway, Japan, Austria, Sweden, Italy, Switzerland,

Group photo of ISSAAT Summer School participants and lecturers at the NTNU Campus Gløshaugen

Germany, UK and France). The participants were MSc and PhD students, and also from aluminium industry.

The school was organized by SFI PhysMet and the UTFORSK project SuReAl.

The aim of the school was to provide a comprehensive overview of state-of-the-art in aluminium alloy technology. The lecturers, from both academia and industry, local and international, focused on the basic metallurgy and mechanics controlling the evolution of microstructure and properties during industrial processing.

AMAG-visit to NTNU/SINTEF in August 2025

On August 12th we had the pleasure of hosting a visit from the AMAG Austria Metal. The AMAG delegation consisted of the following people: Werner Fragner, Head of Corporate Technology; Bernd Prillhofer (MD Casting), Philip Pucher (Head of Casting Technology) and Ramona Tosone (Head of R&D). The visit was a follow up of a visit from the AMAG CEO, Dr. Michal Kaufman and Dr. Fragner to NTNU/SINTEF and Hydro in January 2025 and re-visit from Hydro and NTNU to AMAG in Ranshofen in March. The background is an initiative form Hydro, trying to establish some more collaboration between Hydro, AMAG, NTNU (and SINTEF) and academic institutions in Austria (notably University of Leoben).

In front: Randi Holmestad and Calin D Marioara. 2. row from left: Philip Pucher, Werner Fragner, Ramona Tosone, Bernd Prillhofer, Marisa Di Sabatino, Knut Marthinsen and Lars Edvard Blystad Dæhlie (Foto: Ingvild Runningen).

Prof. Marthinsen gave a short introduction of NTNU, DMSE and SFI PhysMet, followed by presentations about TEM facilities and related Al alloy activities, about SimLab and their research infrastructure and activities and NAPIC (NTNU Aluminium Product Innovation) Center) (GR) while Dr. Kvithyld and Dr. Dispinar presented casting and recycling activities in SINTEF. The presentations were followed by a guided tour to relevant lab facilities, including APT and TEMs in K1; and the mechanical testing facilities (SimLab); forming laboratory facilities (ManuLab) as well as casting/recycling lab facilities in Perleporten.

Miscellaneous

Prof. Di Sabatino was invited to give a lecture at the seminar "Metallurgy in Industry: essential concepts and uses" hosted by The Institute of Engineers (India) on August 30th-31st 2025, Jaipur (India). She gave an online lecture and presented SFI-PhysMet with some examples of research activities from two of the PhD students in the Centre.

The activities related to the establishment of an SFI PhysMet Digital Platform are largely based on technology developed in a number of EU projects (such as the HE projects MatCHMaker, PINK and the COST project EuMINe) related to the European Materials Modelling Council (EMMC), which aims to increase European value creation and ability to solve societal challenges (e.g. within the Green Deal) through increased uptake of materials modelling in European companies. The development of microstructural ontology is led by SFI PhysMet but is done in an EMMC task group in collaboration with other European research actors.

SFI PhysMet has also been contributing to the IAM-I working group 1 on Materials Digitalisation Across the Value Chain and the Task Force on Standards & Norms.

DISSEMINATION AND COMMUNICATION

An important objective of the Centre is to implement and make visible its results. Scientific publications and conference presentations are our main and most important arena to make our research visible in the national and international research communities. However, an important aim is also to facilitate and ensure implementations of new results in the industry sector. Scientists also have a responsibility to build bridges between science and society and explain complex science and its potential impact to the general public.

An important arena to reach out to the public and make information from the Centre easily available is our website **ntnu.edu/phymet**

WEBINARS

Since 2021 we have invited all partners to attend monthly webinars /seminars with scientific presentations on topics relevant to SFI PhysMet members. The presenters are visiting guest scientists to NTNU/SINTEF or just online invitees, PhD opponents, or colleagues and PhD students closely related to SFI PhysMet. The webinars are easily available for all researchers and colleagues from industry partners, as they are presented online. The presentations have been a success, with many participants through the years.

2025	Presenter	Title
March 19th	Prof. Joseph Robson, Univ. of Manchester (UK).	Deformation Enhancement of Diffusion and Precipitation in Aluminium Alloys
April 10th	Prof. Frederic Barlat, Emeritis, Pohang Univ. of Science and Technology, South Korea.	Distortional plasticity and applications
June 26th	Prof. Alan Luo, Ohio State University (USA).	Toward Aluminum Circularity and Manufacturing Sustainability for Automotive Applications
September 26th	Chunan Li, NTNU/KTH PhD defense	Trial lecture: Development of High-Strength and Heat-Resistant Aluminium Alloys Based on Additive Manufacturing Thesis presentation: Solute clustering and early-stage precipitation in Al-Mg-Si alloys
October 17th	Prof. Roland Loge, EPFL (Switzerland).	Architected microstructures and zero-defect tolerance in additive manufacturing of metals and alloys
December 17th	Prof. Babette Toon, Univ. of Clausthal (Germany).	Cast alloys – a key for innovative products
December 18th	Andreas Bugten, PhD defense	Trial lecture: Quality Control in Steel Recycling: Managing Impurities and Tramp Elements PhD thesis: The influence of boron on spheroidal graphite cast iron microstructure

CONSORTIUM MEETINGS

We organize bi-annual consortium meetings with participants from all partners. These meetings are excellent arenas for the dissemination of the latest scientific findings from the five research areas, exchange of ideas, and discussions of current and future research activities.

The SFI PhysMet consortium spring meeting was organised at Sunndalsøra on May 21st-22nd 2025, with Hydro Aluminium as the host. Altogether approximately 60 participants from NTNU, SINTEF, IFE and our industrial partners attended the meeting.

Day 1 was mainly dedicated to presentations of status and recent progress in each of the SFI PhysMet Research Areas (RA), with general overviews from the research area managers and with examples of scientific highlights in each RA, including presentations from 5 PhD candidates.

The focus of Day 2 was 'the way forward' after the RCN Underway Assessment that was completed earlier this year, and which gave a quite favourable evaluation of SFI PhysMet. Our main NFR contact, Øystein Asphjell, was present at the meeting and gave an interesting summary of the SFI IV 'half-way assessment'.

A group of participants on a guided tour at the Hydro Sunndalsøra plant.

The second part of Day 2 was allocated to a group work, with the following agenda/questions:
(i) Scientific foci in the remaining period of SFI PhysMet? In particular with respect to 'new 'PhDs og postdocs' (when relevant)

1. Increased reciprocal mobility between research partners and user partners? What and how?
2. A roadmap for 'the physical metallurgy of recycling'- Key elements and important aspects to address?

Group photo at the SFI PhysMet Consortium meeting at Hydro Sunndalsøra.

Group photo from the consortium meeting in Trondheim, 29-30. October 2025.

Participants at the Consortium meeting in Trondheim attentively following a presentation

The SFI PhysMet Fall Consortium meeting gathered record high 73 participants at Radisson Blu Royal Garden Hotel, 29-30. October 2025.

Day 1 was allocated to presentations of the status and research highlights as well as a brief overview of research plans from each of the 5 research areas. At the end of this session, we had an interesting presentation of 'The Hangarbrua project', presented by Principal Engineer Cato Dørum from Norwegian Public Roads Administration.

Day 2 started with a very nice and interesting presentation by Professor Øystein Grong: Fundamentals of Extrusion-Based Aluminium Welding and Additive Manufacturing: A Retrospective Review of the HYB Process Development. The presentation was very well received by the audience.

The presentation was followed by a poster session, with the presentation of 13 posters, many of them presented by project students (based on summer job projects and ongoing specialization projects). The poster session gave ample room for the students to present themselves to the industry partners and for lively discussions both at the posters and between the Consortium meeting participants.

The Consortium meeting was finalized with group discussions on the following topics;

1. Advanced characterization, recycling and alloy development
2. Multiscale modeling and digital tools
3. 3D printing and innovative joining methods
4. Spin-off / new project initiatives
5. Recruitment (MSc / PhD / industry)

Also in 2025, the Centre was presented at MATERIALDAGEN at NTNU Campus Gløshaugen on October 2nd, which has been a tradition for the Centre since its start. This is an important arena for recruiting and making the Centre known among the young NTNU students and future materials scientists.

As a part of their specialization project, all the students in the Physical Metallurgy group at the Department of Materials Science and Engineering presented their work at a common seminar on November 28th. Among these students, many had projects within the SFI PhysMet and in close collaboration with the industry partners.

INTERNATIONAL CONFERENCES AND MEETINGS

Also during 2025, the SFI PhysMet researchers have attended and presented their results at a number of international scientific conferences and meetings, as exemplified below.

Professor Knut Marthinsen and Postdoc Jianbin Xu attended Thermec2025 - International Conference on PROCESSING & MANUFACTURING OF ADVANCED MATERIALS, June 30 - July 4, 2025, University of Tours, France. The THERMEC conference serves as a pivotal platform, uniting professionals including engineers, technologists, and researchers from industry, academia, and government research laboratories across the world. The conference facilitates the presentation of their research discoveries within the overarching realm of science and technology encompassing the processing, fabrication, and manufacturing of advanced materials. Prof. Marthinsen gave an invited talk with the title: *Application of Artificial Neural Networks for Microstructure Models ALFLOW and ALSOFT*, while Dr. Xu gave an oral presentation with the title: *A Novel Modelling Framework for the Portevin Le Chatelier Effect in AA5182 Alloy*. Prof. Ole Runar Myhr from Hydro also attended the conference and gave an inspiring presentation on *Thermomechanical Testing and Precipitation Modelling of Al-Mg-Si Alloys for Hot Forming Applications.*

The TEM-group at NTNU/SINTEF was well represented at EUROMAT in Granada (Spain) in September 2025. Senior researcher Calin D Marioara, SINTEF was chair for the lightweight alloys session and held a talk titled *"The Effect of Si Additions to an Industrial 7xxx Aluminium Alloy in the Context of Recycling"*. Both PhD candidates Håkon Korsvold and Inga Konow presented posters with titles: *"The effect of Zn on grain boundary segregation and IGC in Al-Mg-Si-Cu alloys"* (Korsvold) and *"The effect of deformation on Al-Mg-Si(-Cu) alloys"* (Konow). Senior researcher Jesper Friis also joined for the final day and held a presentation titled "Digital representation of physical metallurgical knowledge".

SFI PHYSMET IN MEDIA

Opening of the Hangar Bridge in Trondheim

The Hangar Bridge is a pedestrian and bicycle bridge in Trondheim, Norway, which was opened earlier this fall. It is made of recycled aluminium from the decommissioned oil platform Gyda, making it the first of its kind in the world. Some parts of the bridge have also been welded by Laser-arc Hydrid Welding, which is also an important research topic in SFI PhysMet.

Statens Vegvesen websider: 19. June 2025
These are the parties involved in the Hangar Bridge project: Leirvik AS has designed the bridge together with COWI, and has collaborated with Hydro, Aker Solutions and Stena on the recycled bridge deck. ***The Norwegian Public Roads Administration has a close research collaboration with Sintef and the Norwegian University of Science and Technology (NTNU), where the Norwegian Public Roads Administration is a partner in SFI PhysMet, a centre for research-based innovation at NTNU.*** *Winsnes AS has carried out the groundwork for the Hangar Bridge.*

https://www.vegvesen.no/fag/fokusomrader/forskning-innovasjon-og-utvikling/pagaende-programmer-og-prosjekter/fjordx/nyhetsarkiv/na-er-hangarbrua-loftet-pa-plass/

The pedestrian bridge 'Hangar brua'. Foto: Vegard Thorvaldsen/Statens vegvesen

GRAND ARM2 inauguration in Trondheim

As a part of the large-scale infrastructure project NORTEM II, funded by the Research Council of Norway, a new JEOL JEM-ARM300F2 “GRAND ARM2” has been installed at NTNU in Trondheim. The Norwegian Centre for Transmission Electron Microscopy (NORTEM) is a nationally coordinated initiative by the two leading Norwegian TEM groups in Norway, at UiO and at NTNU and with three partners: SINTEF, NTNU and UiO.

In this connection, an inauguration to officially open the new instrument was organized at NTNU in Trondheim on December 2nd and 3rd, 2025, including a lunch-to-lunch seminar with international renowned speakers, presenting possibilities and results from modern transmission electron microscopy (TEM) research. More than 100 participants joined the official opening of the JEOL JEM-ARM300F2 “Grand ARM” transmission electron microscope (TEM).

The new TEM instrument will clearly be an asset also for SFI PhysMet enabling the possibility to dive even deeper into the ‘atom scale world’ of aluminium alloys, as well as other materials we investigate within the SFI, in our endeavor to make stronger, more durable and ‘greener’ materials and material solutions, in close collaboration with our partners and Norwegian metal-based industry

https://www.adressa.no/nyheter/trondheim/i/Okb0kO/supermikroskop-det-byr-paa-fantastiske-muligheter.

8 **NYHETER** LØRDAG 29. NOVEMBER 2025 **ADRESSEAVISEN**

Fysikkforsker Ursula Ludacka gleder seg over å kunne ta i bruk et nytt supermikroskop.

Forskerne på NTNU samarbeider med flere industriaktører.

FAKTA

NTNUs nye mikroskop

Navn: JEOL GrandARM (transmisjonselektronmikroskop)
Pris: Over 60 millioner kroner (inkludert spesialbygget laboratorium)
Plassering: Underjordisk laboratorium i Realfagbygget på Gløshaugen
Oppløsning: Kan se detaljer mindre enn 60 picometer – rundt en milliondel av bredden på et hårstrå
Hva det gjør: – viser plasseringen av enkeltatomer – avslører feil og defekter i materialer – kan kombinere bildeinformasjon og grunnstoffanalyse samtidig

Supermikroskop

– Det byr på fantastiske muligheter

TRONDHEIM: Det nye mikroskopet til NTNU har en prislapp på 60 millioner kroner.
– Det byr på fantastiske muligheter, sier fysikkforsker Ursula Ludacka.

Tenk deg et hårstrå som er splittet opp i en million like deler. Så små ting kan forskerne ved NTNU studere med det nye mikroskopet sitt.

Men det er ikke *hår* forskerne bruker det tre meter høye apparatet til.

– Vi kan observere metaller, batterimaterialer og elektroniske komponenter helt ned på atomnivå, sier den entusiastiske senioringeniøren Ursula Ludacka.

Sammen med flere kolleger ved Institutt for fysikk har hun tatt med Adresseavisen ned i et underjordisk laboratorium på Gløshaugen.

Kjellerrommet er bygget spesielt for mikroskopet. Det må ta en del av skylden for prislappen på 60 millioner kroner.

Laben er en del av den nasjonale infrastrukturen NORTEM og er finansiert av Norges forskningsråd og NTNU. Sintef og Universitetet i Oslo er med i samarbeidet.

– Som du ser er det ikke mobildekning her, smiler senioringeniør Bjørn Gunnar Soleim.

Mikroskopet er ekstremt følsomt. Derfor står instrumentet på en én meter tykk betongkloss. Vegger, gulv og tak er kledd med spesielle metallplater som skjermer for elektromagnetiske felter.

– Kroppsvarme og snakking er nok til å påvirke målingene. Derfor fjernstyrer vi mikroskopet fra naborommet, forklarer Soleim.

Kan gi bedre batterier

Forskerne håper mikroskopet blant annet kan bidra til å skape batterier med lengre levetid.

– Dagens batterier trenger ofte sjeldne metaller som er vanskelige og lite bærekraftige å hente ut. Hvis vi vet mer om hva som skjer på atomnivå, kan vi utvikle løsninger som krever mindre av disse stoffene, sier senioringeniør Ursula Ludacka.

NTNU samarbeider med flere industriaktører. De vil få nytte av arbeidet i det underjordiske laboratoriet.

– Her kan vi se hvordan bittesmå strukturer og defekter inne i metallet påvirker styrken. Denne kunnskapen kan gi oss sterkere og lettere materialer, forklarer førsteamanuensis Magnus Nord ved Institutt for fysikk.

En viktig del av arbeidet er studier av aluminiumslegeringer, hvor forskerne studerer effekten av resirkulering.

– Uante muligheter

Fra før har NTNU og Sintef tre andre såkalte transmisjonselektronmikroskoper i drift. Men ingen av dem er i nærheten av kapasiteten til det nye.

– De andre mikroskopene brukes fortsatt. Men dette er noe helt annet, det blir som å sammenligne dagens smarttelefoner med en Nokia fra 2011, sier professor Ton van Helvoort.

Selv om metaller og energimaterialer er hovedfeltet, åpner mikroskopet også for forskning innen bioteknologi.

– Vi kommer til å samarbeide med andre fagområder. Mikroskopet gir uante muligheter også innen medisinsk forskning. Bare tenk hvor mye kunnskap man kan hente ut om virus og bakterier, sier Ludacka.

> “ – Vi kan observere metaller, batterimaterialer og elektroniske komponenter helt ned på atomnivå
>
> **Ursula Ludacka**

Førsteamanuensis Magnus Nord håper mikroskopet blant annet kan bidra til å skape batterier med lengre levetid.

Et nasjonalt instrument

Innvielsen av mikroskopet markeres med et todagers seminar på NTNU tirsdag og onsdag.

Rundt hundre deltakere fra universiteter, forskningsmiljøer, industri og leverandørmiljøer påmeldt.

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PERSONELL
SFI PHYSMET

CENTRE ADMINISTRATION

Knut Marthinsen	NTNU	Centre Director
Marisa Di Sabatino	NTNU	Deputy Centre Director
Torleif Nordskog	NTNU	Adminsitrative Coordinator
Magnus Eriksson	SINTEF Industry	Scientific Coordinator

KEY RESEARCHERS
RESEARCH AREA 1. MULTI-SCALE MATERIAL ANALYSES

Randi Holmestad	NTNU	Multi-scale material analyses
Sigurd Wenner	SINTEF Industry	Nano-/microstructure characterization (TEM and APT)
Marisa Di Sabatino	NTNU	Material-processing and characterization (GDMS and GDOES)
Calin D. Mariora	SINTEF Industry	Nano-/microstructure characterization (TEM)
Yanjun Li	NTNU	Scale and process bridging methodologies
Siri Marthe Aarbo	SINTEF Industry	Materials, processing and properties
Ruben Bjørge	SINTEF Industry	Nano-/microstructure characterization (TEM and APT)
Tina Bergh	NTNU	Nano-/microstructure characterization (TEM, FIB, SEM)
Jørgen Sørhaug	SINTEF Industry	Aluminium welding
Tor S. Haugland	SINTEF Industry	Machine Learning
Erik Wahlström	NTNU	Microstructure characterization (XPS)

RESEARCH AREA 2. SCALE AND PROCESS BRIDGING METHODOLOGIES

Yanjun Li	NTNU	Scale and process bridging methodologies
Bjørn Holmedal	NTNU	Crystal Plasticity, microstructure- and property modelling
Knut Marthinsen	NTNU	Microstructure-, texture and property modelling
Tomas Manik	NTNU	Crystal plasticity modelling
Emre Cinkilic	NTNU	Microstructure modeling
Xuezhou Wang	NTNU	Atomic and microstructural modelling of clustering and precipitation kinetics
Sylvain Gouttebroze	SINTEF Industry	Materials modelling
Qiang Du	SINTEF Industry	Thermodynamical and microstructure modeling
Ole Martin Løvvik	SINTEF Industry	Atomic scale modelling
Yijang Xu	SINTEF Industry	Materials modelling
Tor Strømsem Haugland	SINTEF Industry	Atomic scale modelling
Xiaobo Ren	SINTEF Industry	Microstructure modelling, Welding process
Victor Fachinotti	SINTEF Industry	Thermodynamic and microstructure modelling
Kai Zhang	SINTEF Industry	Cystal plasticity modelling
Daniel Machand	SINTEF Industry	Atomic and microstructure modeling

RESEARCH AREA 3. SUSTAINABLE AND HIGH-PERFORMANCE MATERIAL DEVELOPMENT

Astrid Marthinsen	SINTEF Industry	Sustainable and high-performance material development
Kjerstin Ellingsen	SINTEF Industry	Sustainable and high-performance material development
Marisa Di Sabatino	NTNU	Material-processing, properties and characterization
Qiang Du	SINTEF Industry	Thermomechanical processing
Kai Zhang	SINTEF Industry	Sustainable and high-performance material development
Jinsong Hua	IFE	Computational material processing

RESEARCH AREA 4. INNOVATIVE PROCESSING AND JOINING METHODS

Magnus Eriksson	SINTEF Industry	Thermo-mechanical processing and welding
Ivan Bunaziv	SINTEF Industry	Laser materials processing; process study and stability, microstructure and properties
Xiaobo Ren	SINTEF Industry	Materials, processing and properties
Ida Westermann	NTNU	Thermo-mechanical processing, microstructure and mechanical properties
Jens C. Werenskiold	NTNU	Thermo-mechanical processing, microstructure and mechanical properties
Tomáš Mánik	NTNU	Materials, processing and properties, Material modelling
Nima Razavi	NTNU	Fatigue and fracture of metallic materials and structures. Properties of additive manufactured materials
Siri Marthe Aarbo	SINTEF Industry	Materials, processing and properties
Jørgen Sørhaug	SINTEF Industry	Materials, processing and properties
Aritra Sarkar	SINTEF Industry	Materials, processing and properties
Bård Nyhus	SINTEF Industry	Materials, processing and properties
Calin Marioara	SINTEF Industry	Nano-/microstructure characterization (TEM and APT)
Ragnhild Aune	SINTEF Industry	Welding, processing and properties
Marwan Dominik Khider	SINTEF Industry	Welding, Laser Arc Hybrid Welding, Processes
Daniel Sørlie	SINTEF Industry	Welding, Arc Welding, Processes
Sigurd Wenner	SINTEF Industry	Nano-/microstructure characterization (TEM and APT)
Ruben Bjørge	SINTEF Industry	Nano-/microstructure characterization (TEM and APT), material physics
Kjerstin Ellingsen	SINTEF Industry	Materials, processing and properties
Asle Joachim Tomstad	SINTEF Industry	
Kush Pragneshbhai Mehta	SINTEF Industry	

RESEARCH AREA 5. DATA, SHARING AND DIGITAL PLATFORMS

Jesper Friis	SINTEF Industry	Data, sharing and digital platforms
Sylvain Gouttebroze	SINTEF Industry	Materials modelling and digital platform
Tomas Manik	NTNU	Crystal plasticity modelling and digital platform
Terence Coudert	SINTEF Industry	Data, sharing and digital platforms
Stephane Dumoulin	SINTEF Industry	Materials modelling, digital platform
Tor S. Haugland	SINTEF Industry	Data sharing and digital platforms

VISITING RESEARCHERS

Frederic Barlat	POTECH, Sør-Korea og Univ. of South Brittany, Frankrike	Metall-bearbeiding og forming – aluminium og stål
Alan Luo	The Ohio State Univ	Aluminium sirkularitet og bærekraft i produksjon av biler og bildeler

POSTDOCTORAL RESEARCHERS WITH FINANCIAL SUPPORT FROM THE CENTRE BUDGET

Jianbin Xu	2024-2026	Laser-based welding of steel and aluminium alloys
Emre ÇİNKILIÇ	2025-2027	Through scale and through process modelling.
Ali Elashery	2025-2027	Microstructural characterization of recycled aluminum alloys under various manufacturing processes.

PHD STUDENTS WITH FINANCIAL SUPPORT FROM THE CENTRE BUDGET

Ingvild Runningen	2021 - 2025	New wires for welding of aluminium alloys
Andreas Voll Bugten	2021 - 2025	The effect of trace elements on the microstructure development and mechanical properties of cast irons.
Xuezhou Wang	2021 - 2025	Develop precipitation model with improved nucleation concepts
Supreet Kaur	2023 - 2026	Effect of trace elements on recycled Al alloys
Håkon Longva Korsvold	2023 - 2026	Materials Physics and Transmission Electron Microscopy
Jan Konkel	2024 - 2027	Development of Low Transformation Temperature (LTT) Steel Alloys for Welding and Additive Manufacturing Applications
Inga Dahlen Konow	2024 - 2027	The effect of deformation on 6xxx Al-alloys
Hitesh Kumar	2024 - 2027	The Corrosion protection of floating structures using laser welding technology
Thyra Rolfseng	2025 - 2028	In-situ studies of precipitation in Aluminium.
William F. Thyholdt	2025 - 2029	Through scale and through process modelling.
Armel Perrotin	2025 - 2028	Si powders for Additive Manufacturing.

PHD STUDENTS WORKING ON PROJECTS IN THE CENTRE WITH FINANCIAL SUPPORT FROM OTHER SOURCES

Gabriela Kazimiera Warden	FME Susoltec	Quartz crucibles for PV silicon solidification (Disputation 27 May)
Chunan Li	NFR KPN SumAl	Clustering and precipitation in Al-alloys (Disputation 26 September)
Hassan Moradi Asadkhandi	NFR FriNatek	Crystal Plasticity (Disputation 6 June)
Magnus Reiersen	Institutt-PhD SINTEF	Modelling and experimental framework for accelerated development of materials for Laser Powder Bed Fusion technology with application to Al alloys.
Håkon Linga	SFI Manufacturing	3D-printing

MASTER STUDENTS

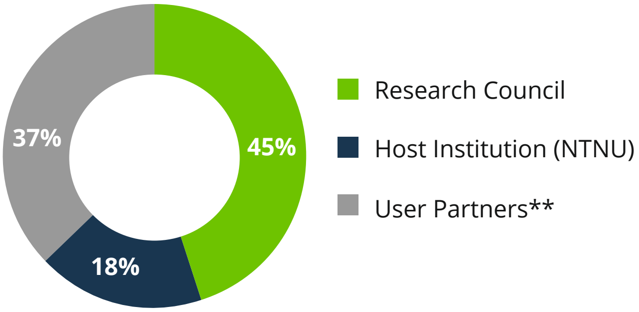
Rajetha Sutha	Acicular ferrite promotion in deep laser welding
Henrik Elton	Novel welding wires for high-strength aluminium applications
Henrik Reberg	Welding of microparticle reinforced aluminium composites
Liesbeth Campbell	3D-FIB-TEM of nanoparticle reinforced 7xxx weld materials
Hannah Hareide	Precipitates in Mg- and Si rech 6xxx alloys with different heat treatment
Kristian B. Thevik	Machine learning on precipitates in 6xxx alloys
Ingeborg Feet Nesset	Modellering av presipitering av nåle-formede partikler
Sondre Aarflot Strandheim	Testing and characterization of hot processing of aluminium alloys
Herman Abdul Maajid	Oxidation Kinetics of Silicon Powders
Fredrik Hexum Arvesen	Application of the Artificial Neural Network within metal plasticity
Giovanni Vicenti	Numerical Modelling of Laser-based Additive Manufacturing Process
Hannah Kvalfoss	Experimental characterization and modelling of microstructure of a twin roll cast aluminium alloy
Andreas Narmo	Investigation of the solidification grain refinement behavior of stainless steels
Lars Hafsås	Effect of Solution Treatment on High Pressure Die Casting (HPDC) Alloys
Torbjørn Kamer-Smits	Additive manufacturing of aluminium alloys with super properties at elevated temperatures

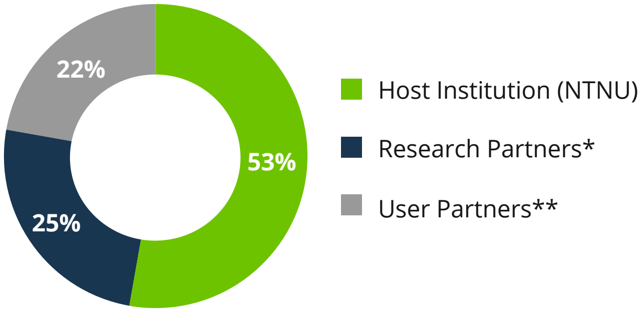
ANNUAL ACCOUNTS 2025

The total budget for the eight year SFI PhysMet centre period is 208 mill NOK. The financing of SFI PhysMet is based on contribution from The Research Council of Norway and cash and in-kind contribution from the user partners and NTNU. Results for 2025:

Funding (1000 NOK)	Amount
Research Council	13 501
Host Institution (NTNU)	5 507
Research Partners*	0
User Partners**	11 337
Total	**30 345**

Costs (1000 NOK)	Amount
Host Institution (NTNU)	16 061
Research Partners*	7 561
User Partners**	6 723
Equipment	0
Total	**30 345**





* *SINTEF AS, SINTEF Manufacturing and IFE.*

** *Hydro Aluminium AS, Elkem AS, Equinor, Benteler, Raufoss Technology, Thermo-Calc Software, The Norwegian Public Roads Administration.*

PUBLICATIONS AND CONFERENCE PRESENTATIONS 2025

PUBLICATIONS DIRECTLY FUNDED BY SFI PHYSMET:

- **Andreas Voll Bugten, Leander Edward Michels Brito Miranda, Ragnvald Mathiesen, Ruben Bjørge, Dmitry Chernyshov, Charlie McMonagle, Wouter van Beek, António Pires, Sonia Simões, Carlos Silva Ribeiro, Yanjun Li, Lars Erik Arnberg, Marisa Di Sabatino.** *Influence of B and Cu on microstructure and eutectoid transformation kinetics in spheroidal graphite cast iron*. Materialia 2025
- **Ivan Bunaziv, T Flint, P Cardiff, Xiaobo Ren, Magnus Carl Fredrik Eriksson.** *Numerical modelling of phase changes in laser materials processing using OpenFOAM.* Materials Science and Engineering 2025
- **Ivan Bunaziv, Xiaobo Ren, Anja Diez, Cristiana Golfetto, G. Rørvik, G. Mälzer, Magnus Carl Fredrik Eriksson.** *Efficient production of offshore structures using laser-based welding.* Conference Series (JPCS) 2025
- **Victor Daniel Fachinotti, Sylvain Gouttebroze, Stephane Christophe Dumoulin, Xiaobo Ren**. *Integrated computational framework for the optimization of the microstructure in additive manufacturing of metals.* Computational Materials Science 2025
- **Tom Flint, Petar Ćosić, Gowthaman Parivendhan, Simon A. Rodriguez, Ivan Bunaziv, Patrick O'Toole, Philip Cardiff.** *Version 3.0 - laserbeamFoam: Laser ray-tracing and thermally induced state transition simulation toolkit.* SoftwareX 2025
- **Astrid Marthinsen, Bartlomiej Adam Gawel, Gabriela Kazimiera Warden, Anna Górska - Ratusznik, Kamila Gawel, Marisa Di Sabatino, Benny Hallam.** *Al doped silica glass: investigation of structural response and defect interactions based on crystalline models.* Physical Chemistry, Chemical Physics – PCCP 2025
- **Xuezhou Wang, Chunan Li, Yijiang Xu, Yanjun Li.** *Revisiting the vacancy diffusion behavior under the influence of solute trapping in dilute alloys.* Acta Materialia 2025
- **Gabriela Kazimiera Warden, Arthika Sivananthan, Astrid Marthinsen, Petra Ebbinghaus, Martin Rabe, Mari Juel, Bartlomiej Gawel, Andreas Erbe, Marisa Di Sabatino.** *Influence of impurities and OH-group content on viscosity, cristobalite formation and bubble evolution in fused quartz crucibles at temperatures for Czochralski process.* Solar Energy Materials and Solar Cells 2025
- **Jianbin Xu, Bjørn Holmedal, Odd Sture Hopperstad, Tomas Manik, Knut Marthinsen.** *Constitutive models for the PLC effect in AA5182 aluminium alloy.* International Journal of Mechanical Sciences 2025

PUBLICATIONS FROM COLLABORATING PROJECTS

- **Hell, C.M., Fröck, H., Bjørge, R. et al.** *Correlative Differential Scanning Calorimetry and (Scanning) Transmission Electron Microscopy Study of the Influence of Interrupted Quenching and Natural Aging of a 6082 Alloy.* Metall Mater Trans A 56, 5726–5739 (2025)
- **Hell, C.M., Lervik, P., Bjørge, R. et al.** *One-stage and two-stage aging of dense and lean 6000 alloys.* J Mater Sci 60, 23792–23806 (2025)
- **Chunan Li, Calin D. Marioara, Constantinos Hatzoglou, Sigmund J. Andersen, Randi Holmestad, Yanjun Li.** *Chemical composition dependent atom clustering during natural aging in Al-Mg-Si alloys.* Scripta Materialia, Volume 257, 2025
- **Vullum, P.E., Celotto, A., Grong, Ø. et al.** *Cold bonding of aluminium to copper by deformation-enhanced diffusion.* Sci Rep 15, 41656 (2025)

- **Vu Ngoc Hai, Abrar Ahmed, Seungwon Lee, Taiki Tsuchiya, Yaofei Zou, Tetsuya Katsumi, Kazuhiko Kita, Pham Mai Khanh, Randi Holmestad, Calin D. Marioara, Kenji Matsuda.** *A comparative investigation of microstructure and mechanical properties in a deformed and aged Al-Mg-Si alloy with high Cu content.* Materials & Design, Volume 260, 2025
- **Oskar Ryggetangen, Yujin Rhee, Elisabeth Thronsen, Calin D. Marioara, Equo Kobayashi, Randi Holmestad.** *The effect of Zn/Mg ratio on the precipitation of T’ in AlZnMgCu alloys.* Materials Characterization, Volume 230, Part A, 2025
- **Yasuhito Kawahara, Calin Daniel Marioara, Christoph Martin Hell, Elisabeth Savitri Thrane, Eva Anne Mørtsell, Jostein Røyset, Randi Holmestad, Kenji Kaneko.** *Effect of Cu addition on atomic clusters and its influence on the dispersion of precipitates in Si-rich Al-Mg-Si alloys.* Materials Science and Engineering: A, Volume 946, 2025
- **Vu Ngoc Hai, Seungwon Lee, Taiki Tsuchiya, Tetsuya Katsumi, Kazuhiko Kita, Pham Mai Khanh, Randi Holmestad, Calin D Marioara, Kenji Matsuda.** *Effect of Deformation on Mechanical Properties and Microstructure of Al-1% Cu-0.96% Mg-0.36% Si (mass%) Alloy.* 2025, Materials Transactions, 66, 220-229,
- **Yasuhito Kawahara, Elisabeth Savitri Thrane, Eva Anne Mørtsell, Jostein Røyset, Randi Holmestad, Kenji Kaneko.** *Cu distribution in intermetallic phases in extruded Al-Mg-Si-Cu alloys.* Journal of Alloys and Compounds, Volume 1012, 2025
- **Emad H. Bartawi, Ghada Shaban, Calin D. Marioara, Oleg V. Mishin, Randi Holmestad, Rajan Ambat.** *The influence of aging temperature on microstructure and intergranular corrosion of Al-Mg-Si alloys with low concentrations of Cu and Zn.* Corrosion Science, Volume 258, 2026
- *Emad H. Bartawi, Ghada Shaban, Calin D. Marioara, Ehsan Rahimi, Ruben Bjørge, Jonas K. Sunde, Yaiza Gonzalez-Garcia, Randi Holmestad, Rajan Ambat. Effect of minor addition of Zn on precipitate crystal structures and intergranular corrosion in 6082 Al-Mg-Si alloys.* Corrosion Science, Volume 249, 2025
- **M.R. Gazizov, R. Holmestad, M.Yu. Gazizova, R.O. Kaibyshev.** *X-ray diffraction pattern analysis of an aged Al-Cu-Mg-Ag alloy.* Materials Characterization, Volume 223, 2025
- **Bjørn Holmedal, Tomas Manik.** *On Labusch’s solid solution depinning and strength estimate.* Proceedings of the Royal Society. Mathematical, Physical and Engineering Sciences, 2025
- **Håkon Edvard Solheimslid Linga, Yubin Zhang, Vegard Brøtan, Bjørn Holmedal.** *Directed Energy Deposition of H13 Steel onto Aluminum Bronze: Imperfections in Multi-material Additive Manufacturing.* Metallurgical and Materials Transactions A, 2025
- **Hassan Moradi Asadkandi, Bjørn Holmedal, Odd Sture Hopperstad, Tomas Manik.** *Study of lattice structure anisotropy by crystal elasticity and plasticity FE simulations.* Mechanics of Advanced Materials and Structures, 2025
- **Hassan Moradi Asadkandi, Tomas Manik, Bjørn Holmedal, Odd Sture Hopperstad.** *Open-source implementations and comparison of explicit and implicit crystal-plasticity finite element methods.* Computers & structures, Vol. 307, 2025
- **Xuezhou Wang, Chunan Li, Yijiang Xu, Yanjun Li.** *Revisiting the vacancy diffusion behavior under the influence of solute trapping in dilute alloys.* Scripta Materialia, Vol. 257, p. 1-7, 2025
- **Qingbo Yang, Chunan Li, Lipeng Ding, Zhihong Jia, Yanjun Li.** *Revealing the atomic ordering in the Al-Cu sub-lattice of T<inf>1</inf> phases in Al-Cu-Li alloys.* Scripta Materialia, Vol. 264, 2025
- **Chun Guo, Shiwei Pan, Feng Qian, Chunan Li, Shun Xu, Xingwang Cheng, Yanjun Li.** *Solute segregation governed atomistic configuration of β-Mg<inf>2</inf>Si/α-Al interface in an Al alloy.* Scripta Materialia, Vol 26, 2025
- **H.W. Bai, Y.H. Gao, Y.J. Liu, X. Wu, P. Xu, J. Ma, F. Qian, X.C. Liu, Yanjun Li.** *Tailoring the microstructural hierarchy and strength-ductility synergy in a Mn-microalloyed Al-Cu alloy via a modified thermomechanical protocol.* Materials Science & Engineering: A, Vol. 921, 2025
- **Shenghua Wu, Bin Chen, Xuezhou Wang,Fuzhu Liu, Hang Xue, Chong Yang, Peng Zhang, Jinyu Zhang, Yuqing Wang, Shengwu Guo, Yong Peng, Gang Liu, Yanjun Li, Alexis Deschamps, Jijun Yang, Guang Ran, Anmin Nie, Jun Sun.** *Unprecedently radiation-tolerant Al alloys via vacancy-mediated anomalous solid-state phase transformation.* Materials Today, Vol. 92. p. 215-225
- **Rania Hendawi, Hendrik Schön, Marisa Di Sabatino.** *Data analysis of industrial czochralski process: Investigation of ingots with structure loss.* Solar Energy Materials and Solar Cells, 2025
- **Nesrin Irmak Köker, Mattia Manni, Martina Giorio, Bjørn Petter Jelle, Marisa Di Sabatino, Gabriele Lobaccaro.** *Defining Challenges of Solar Irradiance Modeling on Facades in Urban Environments: A Systematic Review.* Energy and Buildings, 2025
- **Astrid Marthinsen, Bartlomiej Adam Gawel, Gabriela Kazimiera Warden, Anna Górska - Ratusznik, Kamila Gawel, Marisa Di Sabatino, Benny Hallam.** *Al doped silica glass: investigation of structural response and defect interactions based on crystalline models.* Physical Chemistry, Chemical Physics – PCCP, 2025

- **Gabriela Kazimiera Warden, Arthika Sivananthan, Astrid Marthinsen, Petra Ebbinghaus, Martin Rabe, Mari Juel, Bartlomiej Gawel, Andreas Erbe, Marisa Di Sabatino.** *Influence of impurities and OH-group content on viscosity, cristobalite formation and bubble evolution in fused quartz crucibles at temperatures for Czochralski process.* Solar Energy Materials and Solar Cells, 2025
- **Sirine Houam, Hadjer Ouaddah, Gabrielle Regula, Isabelle Périchaud, Guillaume Reinhart, Marisa Di Sabatino, Lasse Vines, Mathieu G. Silly, Fabrice Guittonneau, Laurent Barrallier, Etienne Pihan, Nathalie Mangelinck-Noël.** *A method to relate the presence of structural defects and impurities and their impact on the electrical activity in silicon for photovoltaic applications.* Solar Energy Materials and Solar Cells, 2025
- **Andreas Voll Bugten, Leander Edward Michels Brito Miranda, Ragnvald Mathiesen, Ruben Bjørge, Dmitry Chernyshov, Charlie McMonagle, Wouter van Beek, António Pires, Sonia Simões, Carlos Silva Ribeiro, Yanjun Li, Lars Erik Arnberg, Marisa Di Sabatino.** *Influence of B and Cu on microstructure and eutectoid transformation kinetics in spheroidal graphite cast iron.* Materialia, 2025

CONFERENCE PRESENTATIONS

- **Andreas Voll Bugten, Marisa Di Sabatino, Yanjun Li, Leander Edward Michels Brito Miranda, Ruben Bjørge, Ragnvald Mathiesen, Paul Sanders, Dale Dewald, Lars Erik Arnberg.** *On the graphite protrusions observed in boron-contaminated spheroidal graphite cast irons.* SFI PhysMet Consortium meeting; 21.05.2025 - 22.05.2025
- **Andreas Voll Bugten, Marisa Di Sabatino, Yanjun Li, Lars Erik Arnberg, Leander Edward Michels Brito Miranda, Ragnvald Mathiesen, Paul Sanders, Dale Dewald.** *Effect of B and Cu on Spheroidal Graphite Iron Microstructure.* SFI PhysMet RA3 meeting; 27.03.2025
- **Emre Cinkilic, Batuhan Dogdu, Tomas Manik, Bjørn Holmedal.** *Bayesian Optimization of KWN Precipitation Model Parameters for Improved Predictive Performance.* Materials Science and Technology Conference 2025; 28.09.2025 - 01.10.2025
- **Qiang Du, Astrid Marthinsen, Kjerstin Ellingsen, Petter Asholt, Martha Indriyati.** *An autonomous high throughput microstructure-property modelling approach toward design of recycling friendly Al-Si foundry alloys.* the 7th International Conference on Advances in Solidification Processes (ICASP–7); 10.06.2025 - 13.06.2025
- **Jesper Friis, Francesca Lønstad Bleken, Elisabeth Thronsen, Sigurd Wenner, Geoffrey Daniel, Alexandre Ouzia.** *CHADA template for scanning electron microscopy and how to represent it in the knowledge base.* EMMC 2025; 07.04.2025 - 10.04.2025
- **Jesper Friis, Francesca Lønstad Bleken, Tor S. Haugland, Sylvain Gouttebroze, Terence Coudert, Emanuele Ghedini, Gerhard Goldbeck.** *Digital representation of physical metallurgical knowledge.* FEMS EuroMat 2025; 14.09.2025 - 18.09.2025
- **Jesper Friis, Francesca Lønstad Bleken, Emanuele Ghedini, Gerhard Goldbeck, Pierluigi Del Nostro.** *Workshop on Interfacial Properties: Open Questions (IPOQ).* Workshop on Interfacial Properties: Open Questions (IPOQ); 20.01.2025 - 30.01.2025
- **Randi Holmestad.** *Studies of Precipitates in age-hardenable Aluminium alloys by advanced TEM.* XXV conference of Applied Crystallography; 07.09.2025 - 10.09.2025
- **Inga Dahlen Konow, Jan Halvor Nordlien, Calin Daniel Marioara, Randi Holmestad.** *The effect of cold deformation on Al-Mg-Si(-Cu) alloys.* Scandem 2025; 11.06.2025 - 13.06.2025
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