

Characterization and chemical analysis

Skilled technicians and scientists, using a range of methods and equipment, will ensure that the properties of silicon ingots and wafers are well established. In our facilities, we offer the following equipment for analysis/characterization of silicon materials:

- Sinton Consulting WCT-100 - Life time of minority charge carriers by Quasi Steady State - Photo Conductance (QSSPC)
 - ✓ Unit built for measurement of life times directly on unpassivated silicon blocks
- Jandel Scientific - 4-point electrical resistivity measurement



- PVScan 6000 - Unique equipment for advanced optical characterization of silicon wafers
 - ✓ Mapping of dislocations, coarse in elusion and grain boundaries
 - ✓ Light Beam Induced Current (LBIC) mapping of solar cell efficiency
 - ✓ Reflectivity mapping
- Hitachi FEGSEM and FEGTEM (Field Emission Gun Scanning/Transmission Electron Microscopy) – High resolution electron microscopy
 - ✓ Determination of crystal orientation in silicon grains
 - ✓ Visualisation and analysis of defects and inclusions
- Thermo Element II GDMS (Glow Discharge Mass Spectroscopy) Elemental impurity analysis in solid samples
 - ✓ For detection of trace element in Si and other materials
 - ✓ Detection limit in the ppb range



About the Norwegian University of Science and Technology (NTNU)

The Norwegian University of Science and Technology (NTNU) in Trondheim represents academic excellence in technology and the natural sciences as well as in other academic disciplines ranging from the social sciences, the arts, medicine, architecture to fine arts. Cross-disciplinary cooperation results in ideas no one else has thought of, and creative solutions that change our daily lives.

The university has 7 faculties and 20 000 students, half of these studying technology or the natural sciences. NTNU has 4300 staff members, where over half in academic or scientific positions, and more than 100 laboratories. NTNU participates in the EU 5th and 6th framework programmes with 46 projects.

The activities within solar cell materials are mainly found at the Faculty of Natural Sciences and Technology at the Department of Materials Science and Engineering and Department of Physics

About SINTEF

The SINTEF Group is the largest independent research organization in Scandinavia, with almost 2000 employees. Our scientists endeavour to develop smart, profitable solutions for clients both in Norway and abroad.

SINTEF aims to create a better society through advances in technology. SINTEF carries out research and development in technology, the natural sciences, medicine and the social sciences and is in a position to take on challenges that demand a cross-disciplinary approach. SINTEF strives continuously to improve the quality of its research and development activities, in the knowledge that it is essential always to be at the cutting edge.

SINTEF operates projects in countries all over the world and our clients will always meet SINTEF as an organization with the power to compete internationally.

For further information please contact:

NTNU:

Otto Lohne
Phone: +47 73 59 27 94
E-mail: otto.lohne@material.ntnu.no

SINTEF:

Aud Nina Wærnes
Phone: +47 93 05 94 28
E-mail: aud.n.warnes@sintef.no



Research and Services
Solar Cell Materials

Contacts:

Characterization and chemical analysis

Ketill Olav Pedersen
Phone: +47 98283980
E-mail: ketill.o.pedersen@sintef.no

Espen Olsen
Phone: +47 98283962
E-mail: espen.olsen@sintef.no

www.ntnu.no

www.sintef.com

The PV-Solar Cell Materials Gemini Centre

The PV-Solar Cell Materials Gemini Centre is the unifying organisational structure for solar cell materials research at SINTEF and NTNU, which includes our joint laboratory facility "Heliosi".

The primary task of the centre is to build a strong research community at a high quality scientific and technological level. An essential task of the Gemini Centre is also making the R&D activities at SINTEF/NTNU visible, as well as ensuring personnel continuity and competence development.

The main scientific- and market related research areas for the Gemini Centre are; production, characterisation, modelling, fabrication and/or use of materials in the solar cell manufacturing system.

Casting -clean room laboratory

In clean room class 1000 environment laboratory facilities, we operate a Crystalox furnace for customized directional solidification of solar grade silicon. We can offer:

- Customized directional solidification of 12 kg, D250mm x H120mm silicon ingots
- Testing of solar grade silicon feedstock
- Testing of new crucibles and coating materials
- Variable cooling regimes
- Tracking of impurity elements and their distribution in ingot



Silicon production and refining

At the SINTEF/NTNU facilities, we offer a range of laboratory and pilot-scale equipment and methods for metallurgical production and refining of silicon feedstock. These include:

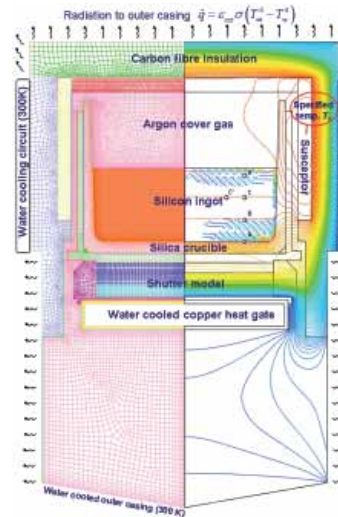
- Rotary plasma furnace for production of high purity SiC from high purity raw materials
- Single phase electric arc furnace for pilot scale production of silicon metal
- Direct production of Si by molten salt electrolysis
- Refining
 - ✓ By filtration
 - ✓ By casting



Physical modelling

Our focus is to understand the processes needed for the production of high quality silicon ingots. Thorough validation of the models is based on the close interaction with experimental activities.

- Heat transport processes
 - ✓ Conduction
 - ✓ Radiation
 - ✓ Forced and natural convection
- Solidification
- Mass transport and related issues
 - ✓ Melt convection
 - ✓ Segregation
 - ✓ Impurity transport in the melt/ingot and cover gas
 - ✓ Impurity dissolution/evaporation from crucible/coating/cover gas
 - ✓ Inclusions and particle precipitation
- Stress analysis
 - ✓ Dislocation multiplication
 - ✓ Residual stresses
- Impact of impurities and dislocations on minority carrier lifetime



Etching and preparation laboratory

In order to facilitate characterization and analysis of silicon ingots and wafers, we can offer:

- Cutting of ingots
- Mechanical and chemical polishing
- Specialised chemical etching facilities available for PV-scanning



Thin films and nanomaterials

An activity in thin films and quantum structures for solar cells has recently been started. SINTEF/NTNU has facilities for deposition and characterisation of various materials (semiconductors, oxides, nitrides etc). The focus areas are:

- Deposition by molecular beam epitaxy (MBE), pulsed laser deposition (PLD), chemical vapour deposition (CVD) and magnetron sputtering
- Thin film characterisation (AFM, XRD, TEM, PL)
- Solar cell modelling and characterisation
- Third generation solar cells



Contacts:

Casting - Clean laboratory & Silicon production and refining:

Otto Lohne
Phone: +47 73592794
E-mail: otto.lohne@material.ntnu.no

Eivind Johannes Øvrelid
Phone: +47 98230449
E-mail: eivind.j.ovrelid@sintef.no

Physical modelling:

Ernst Arne Meese
Phone: +47 98283898
E-mail: ernst.a.meese@sintef.no

Etching and preparation laboratory:

Harsharn Tathgar
Phone: + 47 95861523
E-mail: harsharn.tathgar@sintef.no

Thin films and nanomaterials:

Turid Worren
Phone: +47 73590386
E-mail: turid.worren@ntnu.no

Rune Bredesen
Phone: +47 93811279
E-mail: rune.bredesen@sintef.no