

## Silicon Production Research at SINTEF and NTNU

About 50 years ago, the Department of Metallurgy at SINTEF started with research on the production of silicon for the Norwegian industry. During the last decade, the focus has been on low cost silicon for solar applications. Today, SINTEF is doing ground breaking research for a wide range of companies in the solar industry.

### Our main fields of competence

#### Raw Materials

The quality of the raw materials is decisive for the quality of the produced silicon. SINTEF can assist with:

- Testing of SiO reactivity for carbon reductants
- Selection of carbon reductants for
  - Low impurity levels
  - Optimal "reactivity"
- Selection of SiC grades for processing of Si
- Particle size reduction, mechanical activation, screening and classification into narrow particle size distributions



*Production of silicon in the pilot scale reduction furnace at SINTEF*

- Physical purity upgrading by gravitational, magnetic, electrostatic and flotation separation techniques
- Pelletizing
- Measurement of physical properties as porosity, sizing and decrepitation

## Production of Silicon

SINTEF has competence in reaction mechanisms in carbothermic production of silicon and fundamental thermodynamic and kinetic data for these. An important part of the research is the wide range of experimental apparatus suited for high temperature research. This includes equipment for characterization, standardized tests, small scale laboratory equipment, pilot scale equipment and tools for industrial measurements.

SINTEF has a single phase pilot scale reduction furnace with a 440kVA power supply. This furnace is capable of producing silicon through carbothermic reduction of quartz using carbonaceous materials like charcoal, coal, coke, wood chips or silicon carbide. The furnace can be used to investigate the difference between existing and new raw materials or new process parameters. The composition of the flue gas can be measured to see the effect of different process parameters on environmental impact. The following range of process parameters is possible:

	U, V	I, A
AC	10 – 215 V	50 – 5700 A
DC	10 – 300 V	100 – 10000 A

## Refining of Silicon

SINTEF has a wide range of furnaces that can be used to refine silicon using:

- Slag-metal processes
- Filtration
- Gas purging
- Vacuum treatment
- Plasma treatment

## Refractory Materials for Clean Silicon

The refractory materials are important because low quality refractories can introduce contamination into the silicon. SINTEF can assist with:

- Selection of graphite and other refractories
- Reactivity tests of refractories



*Temperature measurement during silicon refinement*

- Developing lining concepts based on high purity raw materials and binding systems
- Wettability testing between liquid silicon and refractories

## Thermodynamic calculations

SINTEF has an extensive database with thermodynamic data relevant for Si-production both for furnace process and refining. The database can be used to calculate the distribution between slag, silicon and gas of elements that contaminate solar grade Si. Physical properties of the different phases can also be modeled and simulated. FactSage and its family products, ChemSheet and ChemApp, are the main programs used in the calculations and SINTEF has a high expertise in use of these.



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