



Silicon Metal Treatment

Prof. Merete Tangstad, Prof. Gabriella Tranell
and Dr. Arjan Çiftja

Short Course: 27 Nov 2011, Fiesta Americana Condesa All
Inclusive Resort, Cancun, Mexico

Beginning with an understanding of the types of impurities that occur in silicon, and their detrimental effects on solar cell performance, the course will address topics including impurities both dissolved in silicon such as B, P, Fe, Al, Ti, etc. or present as solid inclusions such as SiC and Si₃N₄. The participants will learn about impurity removal as carried out via metallurgical routes. Methods for measuring impurities in silicon will also be highlighted.

Who Should Attend

This course would be beneficial to corporation and plant managers, engineers, technologists, researchers, and students engaged or interested in the development and implementation of solar grade silicon production and refining through metallurgical routes.

Course Outline

- Effect of impurities on solar cell performance. *Dr. Arjan Çiftja, SINTEF.*
- Characterisation techniques (GDMS, ICPMS, LECO, FTIR, SIMS). *Dr. Arjan Çiftja, SINTEF.*
- The silicon process, unit operations and raw materials. *Prof. Gabriella Tranell, NTNU.*
- Impurity distribution in the Si-furnace. *Prof. Gabriella Tranell, NTNU.*
- Ladle refining for Ca and Al. *Prof. Gabriella Tranell, NTNU.*
- Overview of metallurgical refining processes. *Prof. Merete Tangstad, NTNU.*
- Slag refining of boron. *Prof. Merete Tangstad, NTNU.*
- Vacuum refining of phosphorus and precipitation refining. *Prof. Merete Tangstad, NTNU.*
- Impurity behavior during solidification - refining by solidification, precipitation and leaching. *Dr. Arjan Çiftja, SINTEF.*
- Removal of solid inclusions by settling, filtration and directional solidification. *Dr. Arjan Çiftja, SINTEF.*

The participants will also receive:

- CD with course material
- Certificate of completion
- A copy of instructors recently published articles related to silicon production and refining
- Lunch and refreshments





Merete Tangstad is Professor at the Norwegian University of Science and Technology at the Department of Material Science and Engineering. She received her M.Sc. and Ph.D. at the same institution. Merete Tangstad has worked in the silicon and ferromanganese industry, in Elkem ASA and Eramet for a total of 14 years. Her main research areas are production and refining of silicon, and ferromanganese production. She is co-authors of the book "*Production of manganese ferroalloys*" and contributed as a co-author of two chapters in the book "*Cystal growth of Si for solar cells*" by K.Nakajima and N.Usami. Merete Tangstad has been the leader of the Norwegian Metallurgical Society (2006-2008) and is a member of its board (2008 -). She is a key reader and referee of Infacon, Metallurgical Transactions, Journal of Chemical Education, and Steel Research International.



Gabriella Tranell is Professor at Norwegian University of Science and Technology at the Department of Material Science and Engineering. She holds a M.Sc. in Geotechnology, from the Luleå University of Technology (Sweden) and NTNU (1992), a Ph.D. in Materials Science and Engineering, University of New South Wales, Australia (1998). She was a research scientist at Luleå University of Technology, Sweden (1992-1993), University of New South Wales, Australia (1993-1994), Senior scientist at SINTEF Materials and Chemistry (2001 - 2004), and Research Manager at SINTEF Materials and Chemistry (2004 - 2009). Her fields of expertise include production of solar grade silicon, manganese ferroalloy processes, Iron-and steelmaking, thermodynamics of metallurgical slags etc. She is one a co-organizer of the symposium of "Production, Refining and Recycling of Silicon" at the TMS annual meeting, 2011. Gabriella Tranell is a co-author of two chapters in the book "*Cystal growth of Si for solar cells*" by K.Nakajima and N.Usami.

Arjan Ciftja is a research scientist at SINTEF Materials and Chemistry. He has a Diploma in Physics (2000) and a M.Sc. in Chemistry (2004) from the University of Tirana, and a Ph.D. from NTNU (2009). He was Ass. Pedagogue at the Department of Chemistry, University of Tirana (2000-2005), visiting research scientist at NTNU (2005-2006), research scientist at NTNU and SINTEF (part-time) 2006-2009. His research expertise includes refining and recycling of solar cell silicon and light metals, removal of inclusions from silicon by filtration, settling, and directional solidification, wettability of molten silicon with refractory





materials etc. He has received the Graduate student award from National Renewable Energy Laboratory (2008), Dr.Ing. Haakon Styrís Studiefond Award from The Norwegian Metallurgical Society (2008), and TMS Young Leaders Professional Development Award (2009). Arjan Çiftja is the author of the book “Solar Silicon Refining: Inclusions, settling, filtration, wetting”.

REGISTRATION: <https://www.flogen.com/FraySymposium/registration.php>

