



ALD Vacuum Technologies

High Tech is our Business

SCU450 / SCU800 / SCU1200 / SCU1500 Silicon Crystallization Units

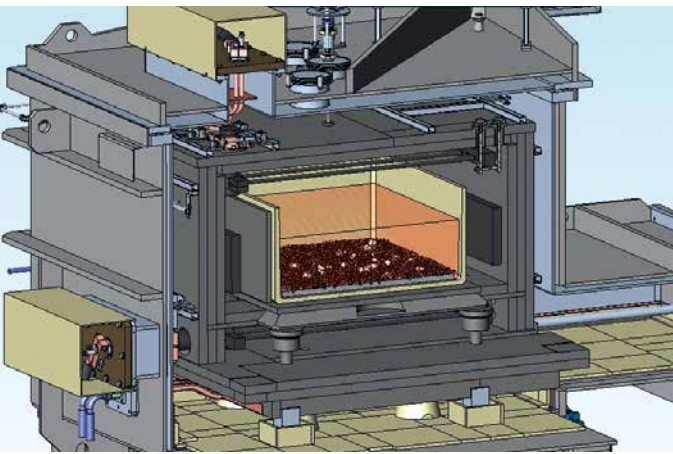
Benchmark for Gen5 to Gen8 Multi- and
Mono-Crystalline Silicon Ingot Production



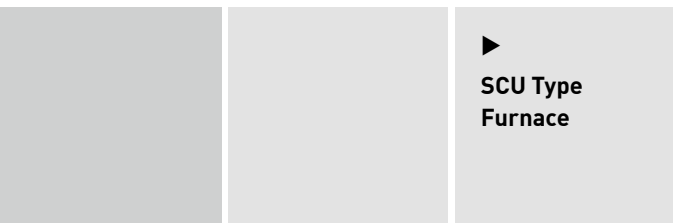
Silicon Crystallization Units (SCU)

Benchmark for Solar-Grade Silicon Ingot Production

ALD's silicon crystallization units are automated furnaces for high-throughput melting and crystallizing solar-grade silicon into ingots for processing into wafers for solar cells. They produce one high-quality multi- or mono-crystalline silicon ingot per cycle.



◀
**Cross section of
ALD's Silicon
Crystallization
Units**



▶
**SCU Type
Furnace**



Sizes and Configurations SCU Model Series

SCU furnace models are available for the Gen5 to Gen8 crucible generation.

The SCU450 and SCU800 systems are configured and optimized for Gen5 and Gen6 silicon ingot production with a capacity range of 400 - 950 kg silicon per cycle corresponding to an annual solar power output of approx. 10 - 15 MWp.

The Next Generation SCU furnace models, SCU1200 and SCU1500, enable substantially lower ingot manufacturing costs and will meet your long term production requirements.

SCU1200 and SCU1500 furnaces are configured and optimized for Gen7 and Gen8 ingot production with a capacity range of 1100 - 1800 kg silicon per cycle corresponding to an annual solar power output of approx. 20 - 27 MWp.

Exclusive Design Features

Top, Bottom and Side Heaters

Independently controllable graphite resistance heaters provide high melt rates, flat temperature profiles and strictly vertical heat flux. The **Top, Bottom and Side Heater** arrangement permits for excellent electromagnetic melt stirring to minimize silicon carbide and nitride inclusions and eliminates seed melting in advanced crystallization processes.

Heat Extraction System

Unique **Triple Heat Gate** system in combination with an **Active Heat Exchanger** enables excellent silicon ingot crystallization and precise control of all important

High-Throughput, Multi- and Mono-Crystalline Silicon Ingot Production

SCU Systems from the Technology Leader

- Gen5 to Gen8 ingot production
- Highest yields and excellent ingot quality
- Intrinsic furnace safety design
- Best system productivity available in the market
- Shortest cycle times and low specific energy/argon consumption
- Lowest cost of ownership



◀ 800 kg Gen6 silicon ingot

▼ Multiple SCU furnace installation with extension modules platform

▼ SCU800 for multi-crystalline ingot production



crystallization parameters and flexibility to adjust and vary the crystallization process as required. The **Active Heat Exchanger** is the key for rapid cool-down of the solidified ingot at the end of the annealing step for higher throughput with large ingots.

Top Loading

The **Top Loading** system provides for excellent accessibility and visibility of the process area and fast, safe and accurate loading/unloading of large silicon ingots using established lifting tools and standard overhead cranes.

It is essential for minimum down time and safe operator conditions during cleaning and maintenance routine.

Advanced Safety Design

SCU systems are equipped with multiple **Advanced Safety Features** reflecting ALD's extensive know how in handling multi-ton loads of liquid silicon and other molten, reactive metals. Inherent operator and facility protection is assured by double layer protection shields of copper and refractory tiles across the entire SCU bottom area, PLC safety

interlocks, continuous diagnostics and high cross-section chamber pressure relief devices in the event of a crucible failure and silicon spill.

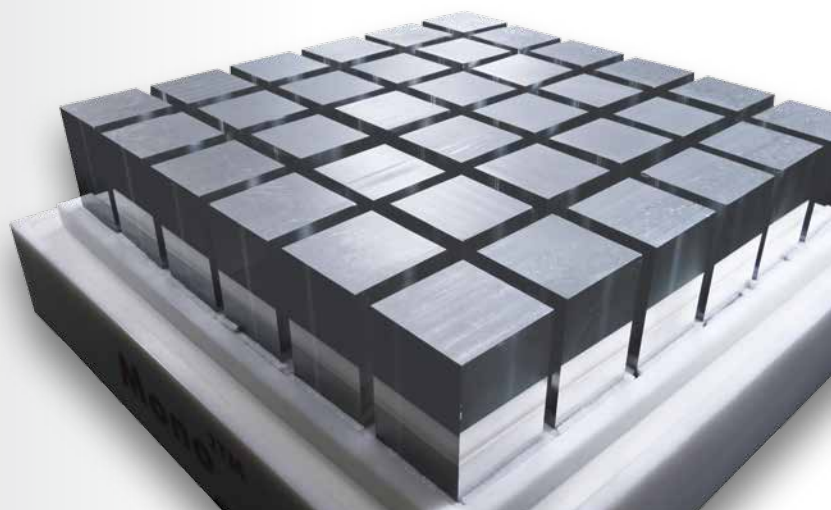
Central Control Center

Up to 24 SCU systems are remotely controlled from a redundant server based **Central Control Center**. Maximum operator safety and comfort includes UPS, flexible process recipe administration and safe process data storage, based on world class SIEMENS PLC's, computers and software.

HPM and Mono²™ Processes

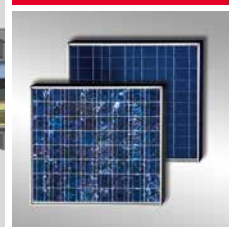
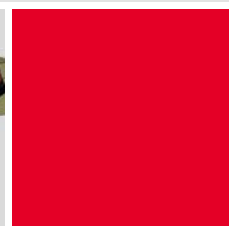
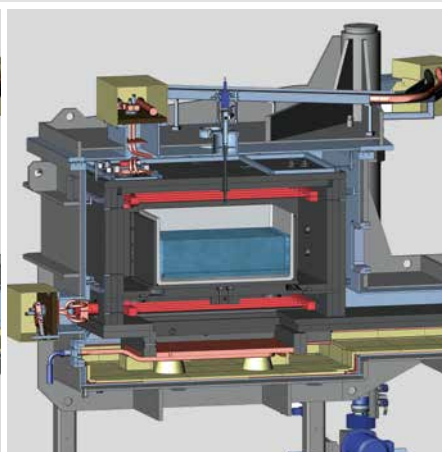
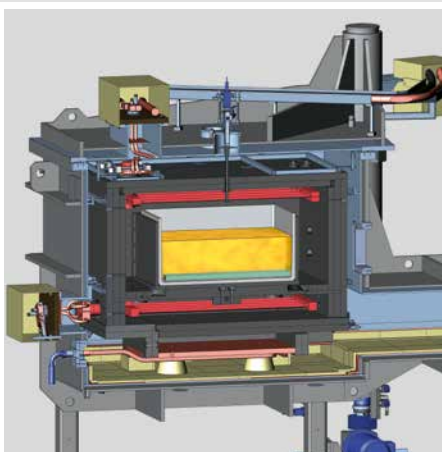
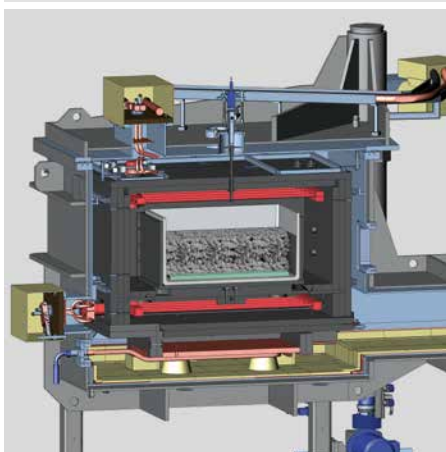
Advanced Silicon Melting and Crystallization

Unique and patented process technology for high-performance multi- and mono-crystalline ingot production



HPM and Mono²™ Process Principle

1. Load multi- or mono-crystalline seeds at crucible bottom
2. Load poly-silicon chunks above seed layer
3. Melt down the feedstock
4. Keep seed layer partially solid
5. Initial uniform and controlled crystal growth on seed layer
6. Grow silicon ingot
7. Cut top, bottom and side from ingots
8. Cut ingot into bricks



HPM and Mono²™

Process Characteristics and Technology Transfer

- Standard SCU systems equipped with additional instrumentation/software meet all requirements for HPM and Mono²™ processes
- Processes for ingots grown from multi- and mono-crystalline seed layers
- Methods for seed manufacturing and replication methods
- Patented technology for seed layer preservation and controlled crystallization start
- Patents: US 8,030,633, US 7,758,696, US 8,048,221, additional patents pending

Premium Ingot Quality

- HPM: High-performance multi-crystalline ingot production
- Mono²™: Mono-crystalline ingot casting
- Substantially higher cell efficiencies compared with conventional ingot casting
- Lower manufacturing cost than mono-CZ process
- Full square cells
- Retrofit process/equipment upgrade and license available for standard ALD SCU systems

Mono²™ bottom plate and ingot with mono crystalline structure



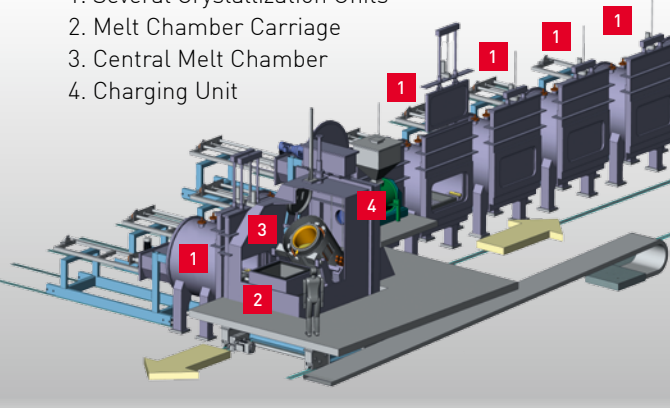
Unique Silicon Melting and Crystallization Concepts and Furnace Designs

VIM Type Furnace

Vacuum Induction Melting & Casting and Crystallization System

Separation of Melting from Crystallization

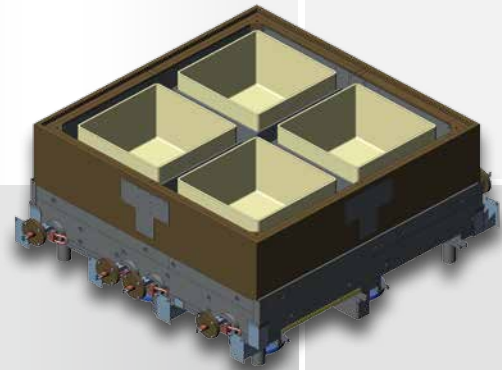
1. Several Crystallization Units
2. Melt Chamber Carriage
3. Central Melt Chamber
4. Charging Unit



SMC Type Furnace

Silicon Melting & Crystallization

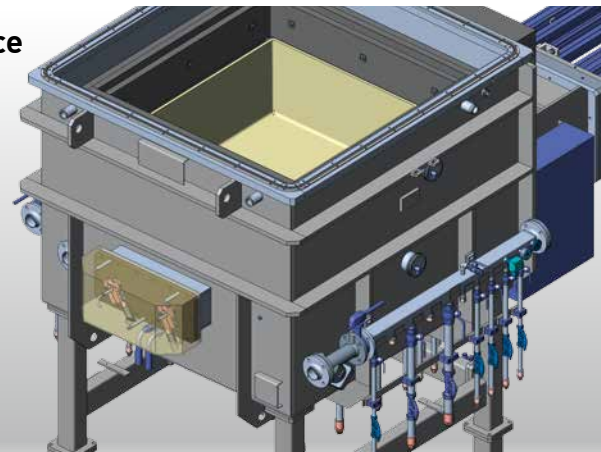
Quad Crucible System



SCU Type Furnace

Silicon Crystallization Unit

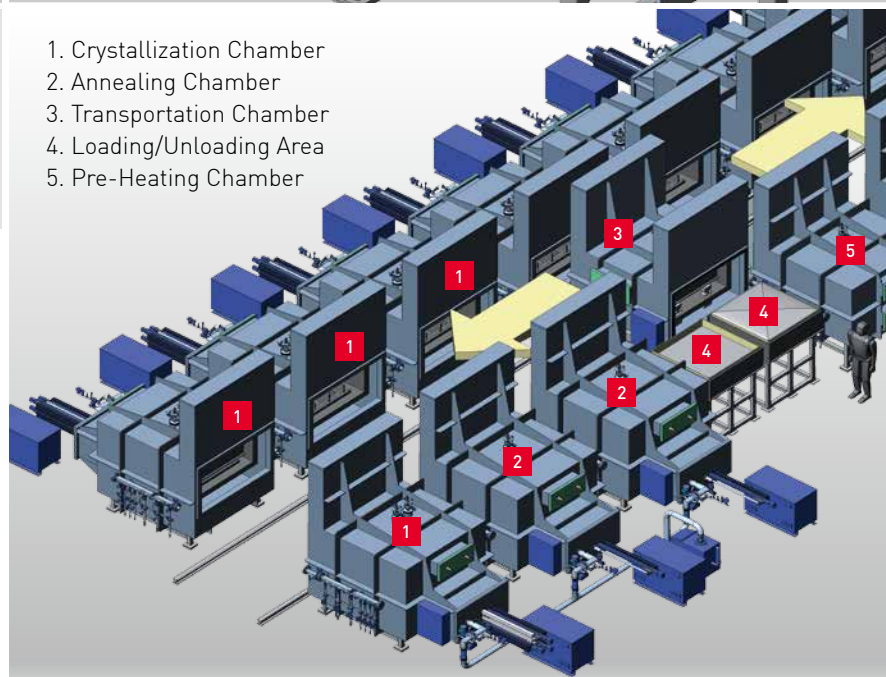
Single Crucible System



PRODUCTION LINE Concepts

Separation of Melting & Casting from Annealing & Cooling

1. Crystallization Chamber
2. Annealing Chamber
3. Transportation Chamber
4. Loading/Unloading Area
5. Pre-Heating Chamber



Precision Engineering & Manufacturing from the Quality Leader

- More than 100 years of experience in design and manufacture of advanced vacuum furnaces
- Worldwide sales and service network
- Several hundred SCU systems equal to more than 5 GWp annual production capacity installed in the world's leading solar industry companies
- Every system meets European safety and quality standards
- Customized solutions and concepts for silicon ingot production
- Unique experience in handling of more than 5 t liquid silicon



Technical Data

		SCU450	SCU800	SCU1200	SCU1500
Crucible / Ingot Generation	[m]	5	6	7	8
Crane Hook Height	[m]	4.8	5.2	5.4	5.4
Overhead Crane Capacity	[t]	2	2	3	3
Max. Operating Temperature	[°C]	1,570			
Ultimate Vacuum	[Pa]	5			
Inert Gas		Ar, He (max. 1,000 mbar)			
Cycle Time	[h]	56 - 62	62 - 68	65 - 71	68 - 74
Connected Power	[kVA]	200	250	400	500
Energy Consumption per Cycle	[kWh/kg]	3,300	5,200	7,200	8,200
Argon Consumption per Cycle	[Nm ³]	60	80	100	120
Cooling Water Consumption	[l/min]	170	190	300	350
Nominal Batch Capacity	[kg]	450	800	1,200	1,500
Batch Capacity Range	[kg]	400 - 550	600 - 950	1,000 - 1,300	1,350 - 1,700
Ingot Crystal Structure		Multi-Crystalline			
Annual Production Capacity	[MW _p]	10 - 13	14 - 16	19 - 23	23 - 27
Retrofit / Upgrade for Advanced Processes (HPM, Mono^{2TM})		Yes			

ALD Vacuum Technologies GmbH

Otto-von-Guericke Platz 1
63457 Hanau, Germany
Phone +49 6181 307-0
Fax +49 6181 307-3290
E-Mail info@ald-vt.de
Internet www.ald-vt.de

USA/Canada

ALD Vacuum Technologies Inc.
18 Thomson Road
East Windsor, CT 06088, USA
Phone +1 (860) 386 7227
E-Mail info@ald-usa.com

Far East (Japan/Korea/Taiwan)

**ALD Thermo Technologies
Far East Co., Ltd.**
Shinjuku Nomura Bldg. 6F
1-26-2 Nishi Shinjuku
Shinjuku-ku
Tokyo 163-0558, Japan
Phone +81 (3) 3340 3726
E-Mail peter.lang@ald-vt.de

China

**ALD-C&K Vacuum Technologies
(Suzhou) Co. Ltd.**
333 Yegang Road
Wujiang Economic and
Technological Development Zone
Suzhou, 215200, P. R. China
Phone +86 512 6385 8833
E-Mail info@ald-cn.com

Russia

ALD Vacuum Technologies GmbH
Daev per., 20
Moskau, Russia
Phone +7 (495) 787 6733
E-Mail ald@metallurg.com.ru