SCU450 and SCU650
Solar-grade Silicon Crystallization Units for Multi-Crystalline and Mono-Crystalline Ingot Production
ALD’s Family of Silicon Crystallization Units (SCU) for Solar-grade Ingot Production

ALD’s crystallization units are stand-alone furnaces for melting and crystallizing of solar-grade silicon into an ingot for subsequent processing into wafers for solar cells. They are based on top and bottom heating and produce one high quality square multi-crystalline or mono-crystalline ingot per cycle.

Unique Crucible Size Range: Gen5 and Gen6
The SCU450 series furnace is available for use of Gen5 crucible generation with a capacity range of 400 - 500 kg per cycle, corresponding to an annual solar power output of approximately 9 MWp/y.

The SCU650 series furnace is available for use of Gen5 or Gen6 crucible generation with a capacity range of 500 - 800 kg per cycle, corresponding to an annual solar power output of approximately 9-12 MWp/y.

Optional Mono™ Process
for production of mono-crystalline Gen5 or Gen6 ingots.

- New: solar cells processed from Mono™ ingots feature full square shape and uniform deep black surface appearance

Active Heat Sink
for constant crystallization rate throughout entire ingot from bottom to top improving ingot quality.

Easy Top-loading
allowing faster and easier loading/unloading and minimum down time during maintenance.

Top & bottom heating arrangement for vertically oriented uniform heat flux and flat temperature profile allowing
- faster melt cycles
- larger ingots
- tight control of crucible bottom temperature distribution
- lower crystallization cost
- perfect fit with Mono™ process upgrade

Optional features are available such as triple heat gate, side heaters and other custom designed options
MULTI- AND MONO-CRYSTALLINE INGOT PRODUCTION

from the Technology Leader

- First to introduce Gen5 furnace (SCU450)
- First to introduce Gen6 furnace (SCU650)
- First to introduce Mono™ process (patented technology)

- Modular hot zone for a minimum
down time during maintenance and for
future update to Gen6 when additional
productivity is required

- Dual-layer spill protection shield with
double layer of copper and refractory tiles,
PLC-safety interlocks, permanent bottom
heater monitoring and high cross-section
chamber pressure relief device

- Mono™ upgrade only available from
ALD using its patented seeded growth plates,
process instrumentation and software

- Central, remote, redundant server-based
control centre for maximum operator
safety and comfort, flexible process recipe
administration and safe process data
storage, based on worldclass SIEMENS
hard- and software

- Open recipe editor for customization
of process recipes

- Dry-pump vacuum system for minimum
maintenance cost, elimination of hydro-
carbons in the process chamber and
facilitation of Ar-recovery system retrofit

- Completely assembled and hot-tested
in German factory prior to shipment,
for minimal on-site installation and
commissioning period

Left: Gen5 ingot with 450 kg
Middle: Multi-furnace installation with
extension modules platform
Right: SCU450/SCU650 for multi-
crystalline ingot production

SCU450 and SCU650
Mono™ Highlights

- Higher cell efficiencies than large grain DS
- Lower manufacturing cost than mono-CZ
- Decreased light-induced degradation (LID) effect due to lower oxygen content

Compatible with existing CZ-cell process, including alkaline [100] pyramid etching (uniform deep black surface appearance)
- Full-square cells
- Retrofit process/equipment upgrade and license available for ALD SCU450/SCU650

Industry Standard Alkaline Etch Wafer and Cell Processing

- Less reflectance loss for higher module power and attractive black module appearance
- SEM image of a pyramid-etch Mono™ wafer
- Typical Mono™ ingot which can be cut into 5x5 Mono™ bricks
**MONO²™ CRYSTALLIZATION**

Unique, patented process technology for mono-crystalline ingot production

**Mono²™ Technology Transfer includes:**
- Process for ingots grown from seed plates
- Technology for seed manufacturing and replication methods
- Instrumentation for controlled start of crystallization
- License to use instrumentation and software for constant crystallization rate ingot growth

**Patents:**
- 8,030,633 US
- 7,758,696 US
- 8,048,221 US
- additional patents pending

**Mono²™ Process Principle**

- Load mono-crystalline seed-plate at crucible bottom
- Load polysilicon chunks on top
- Melt down the feedstock
- Keep mono-crystalline seed-plate partially solid
- Initiate uniform crystal growth on seed-plate enabled by uniform and flat temperature profile
- Grow mono-crystalline ingot
- Cut edges with band saw
- Recover seed-plate for re-use
SCU650
GEN6 INGOTS

Higher quality and lower conversion cost

- Quality – more inside bricks with no contact to crucible wall
- Yield – higher quality inside bricks with Gen6 crucibles
- Throughput – faster than any other silicon crystallization furnace manufactured today
- Uptime – easy to remove and modular hot zone for a minimum down time during maintenance

Advantages of Gen6 Ingots

- More inside bricks
  \( 16/36 = 44\% \text{ versus } 9/25 = 36\% \) with no contact to crucible wall and coating
- Higher mass ingot yield
- Better surface area to mass ratio

SCU650 series for Gen6 multicrystalline ingot production with 650 kg charge weight producing 16 inside bricks per ingot
HIGH VALUE
Engineering & manufacturing from the quality leader

- Many years of experience in design and manufacture of vacuum melting furnaces in the solar, aerospace and specialty material industries
- Worldwide sales and service network
- More than 4 GWp installed base in the world’s leading solar industry companies.
- In-house crystallization, Mono™ pilot line and testing at tech-centers in Germany and USA

ALD Vacuum Technologies GmbH ("ALD") is the Engineering Systems Division of AMG Advanced Metallurgical Group N.V.

ALD is the world-wide market leader in vacuum metallurgy and the technology leader in vacuum heat treatment

The company supplies equipment and turnkey solutions for thermal and thermo-chemical treatment of metallic materials in solid and liquid form

Continuing R&D projects and acquisitions of complementing technologies are further strengthening ALD as a supplier of key technologies in traditional and emerging growth markets

Every furnace is completely assembled and has passed comprehensive performance tests prior to delivery ensuring compliance with factory standards.
## Technical Data

<table>
<thead>
<tr>
<th></th>
<th>SCU450</th>
<th>SCU650</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane hook height</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Overhead crane capacity</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Max. operating temperature</td>
<td>1,570</td>
<td>1,570</td>
</tr>
<tr>
<td>Ultimate vacuum</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Leak rate</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Inert gas</td>
<td>Ar, He (max. 900 mbar)</td>
<td>Ar, He (max. 900 mbar)</td>
</tr>
<tr>
<td>Cycle time</td>
<td>approx. 48 - 55</td>
<td>approx. 58 - 65</td>
</tr>
<tr>
<td>Connected power</td>
<td>210</td>
<td>220</td>
</tr>
<tr>
<td>Power consumption per cycle</td>
<td>3,600</td>
<td>4,800</td>
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<tr>
<td>Ar-consumption per cycle</td>
<td>approx. 60</td>
<td>approx. 70</td>
</tr>
<tr>
<td>Cooling water consumption</td>
<td>approx. 170</td>
<td>approx. 190</td>
</tr>
<tr>
<td>Batch capacity in Gen5 configuration</td>
<td>400 - 500</td>
<td>500 - 800</td>
</tr>
<tr>
<td>Ingot crystal structure</td>
<td>multicrystalline</td>
<td>multicrystalline</td>
</tr>
<tr>
<td>Annual production capacity* (cell power)</td>
<td>approx. 7 - 9</td>
<td>approx. 9 - 12</td>
</tr>
</tbody>
</table>

* Depending on actual crucible dimensions, ingot mass, feedstock quality, wafer thickness, downstream wafering and cell processing.

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<tr>
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<th>MONO&lt;sup&gt;STM&lt;/sup&gt;</th>
</tr>
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<tbody>
<tr>
<td>Ingot crystal structure</td>
<td>&gt; 80 % monocrystalline</td>
</tr>
<tr>
<td>Brick crystal structure</td>
<td>Monocrystalline</td>
</tr>
<tr>
<td>Cell surface texture/etching</td>
<td>Suitable for (100) pyramid texture/alkaline</td>
</tr>
<tr>
<td>Cell appearance</td>
<td>Full-square, deep black</td>
</tr>
<tr>
<td>Cell efficiency gain</td>
<td>Plus 1-2 % points (depending on cell process)</td>
</tr>
<tr>
<td>Cycle time</td>
<td>50-58 hours (Gen5)</td>
</tr>
<tr>
<td>Seed plate type</td>
<td>Monocrystalline (100) texture, recoverable</td>
</tr>
<tr>
<td>Seed plate recovery process</td>
<td>Included in technology transfer with license</td>
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</tbody>
</table>

ALD provides assistance in factory layout and basic engineering for multiple furnace layouts.
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