



CISARIS

Furnace with High End
Rapid Thermal Processing
for an Optimized CIGS
Absorber Formation

CISARIS – Selenization/Sulphurization

with High End Rapid Thermal Processing for an Optimized CIGS Absorber Formation

SINGULUS TECHNOLOGIES

*Developer, Enabler and Supplier
for CIS/CIGS and CdTe Solar Cells*

Solar cells can be categorized according to the applied production process and used materials, for example in crystalline and thin-film solar cells.

In thin-film solar technology a large glass panel forms the base material, on which a relatively thin layer of 1 to 2 μm of a photoactive compound is applied. Amongst others, alloys consisting of

copper, indium, gallium and selenium or sulfur (CIGS), compounds of cadmium and tellurium (CdTe) are used in this process.

Due to a superior performance under low light intensities thin-film solar cells deliver electrical power already in the early morning and later evening hours or at clouded sky. In addition the panels are more tolerant against local shadowing.



SINGULUS offers leading-edge production systems for CIGS & CdTe thin-film solar panels made of glass and flexible substrates:

- *Cleaning and etching machines*
- *Metal free glass washing machines*
- *R & D tools for CIGS development*
- *Selenisation & sulphurisation furnaces*
- *Sputtering & evaporation systems*
- *Deposition systems for cadmium-free buffer layers*

- 1 Large production furnace CISARIS
- 2 LAB-CISARIS



CISARIS – Selenization/Sulphurization

*with High End Rapid Thermal Processing (RTP)
for an Optimized CIGS Absorber Formation*

Also thin-film solar cells do not suffer so much in their performance at high solar panel temperatures occurring at full sun intensities. Furthermore, thin-film solar panels can be used as an architectural design element for the frontside or the roof of buildings due to their homogenous surface color and attractive visual appearance.

For CIGS cells the absorption layer is comprised of copper, indium, gallium as well as selenium and partly sulfur compounds. These thin-film cells have achieved laboratory efficiency levels of over 20 %. The efficiency of modules is in a range from 13 to 17 % depending on the module size. SINGULUS TECHNOLOGIES is increasingly consulted as a development partner for highly efficient solar cells and chosen as preferred machine supplier by leading solar cells producers for the relevant machines.

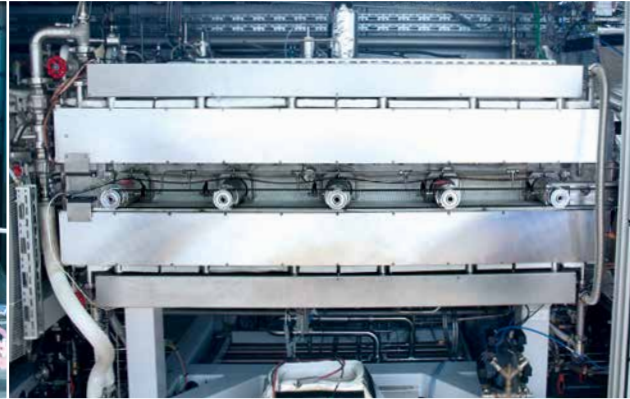
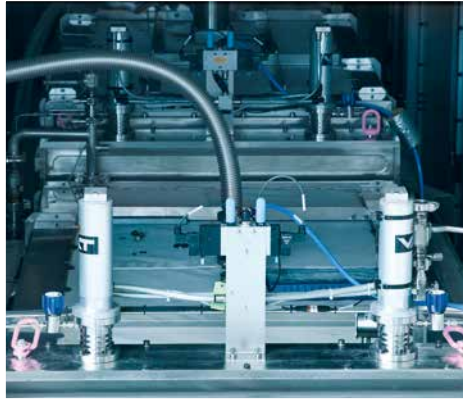
With our production equipment we are one of the few companies able to equip both efficiently running factories for the manufacturing of CIS/CIGS thin-film modules as well as single machines and turn-key lines for the production of next generation solar cells.

The CISARIS RTP furnace is an inline rapid thermal processing equipment, designed for the CIGS absorber formation on large area glass substrates. CISARIS consists of a handling station, a vacuum tight process section, and a return conveyor and is optimized for the mass production of CIS solar modules. The main features of the CISARIS include a high uptime and mechanical yield as well as a fast cycle time which, in combination with the robust selenisation and sulphurisation process, lead to a production capacity of over 25 MWp per year (depending on configuration, see page 7). CISARIS is a proven innovative and reliable equipment, which has been continuously further developed at SINGULUS based on previous generations of selenisation ovens. CISARIS can safely handle the thermal processing of large glass substrates of over 1 sqm at temperatures up to 600 °C and beyond under a toxic and corrosive gas atmosphere. High heating and cooling rates combined with an excellent temperature homogeneity during all process stages are the key factors, which allow the formation of an optimal CIGS_{Se} absorber, required for the production of high efficiency solar modules.

Main Characteristics

- Third generation inline selenisation & sulphurisation furnace with optimized cycle time
- Rapid heating (up to ~ 4 °C/s) of large substrates with metal precursor coating (CIG)
- Homogeneous gas distribution and low gas consumption through optimized inlet system
- Introduction of H₂S & H₂Se gas at various stages of the process possible
- Uniform heating of large substrates up to 600 °C and beyond by using optimized IR radiators for achieving the required crystal quality
- Uniform cooling of the substrate to avoid glass warpage
- Excellent temperature control (mean variation < 5 °C) at all process stages
- Process under vacuum and at atmospheric pressure
- Oxygen and water vapor free process atmosphere guaranteed through pump/purge cycles and continuous gas monitoring
- Excellent maintenance concept with maximum accessibility of all machine components
- Proven safety system based on a solid risk management and safety engineering





Key Components

The CISARIS machine consists of the following key components (example):

- Handling section:
Transport of the substrates between the fab automation and the CISARIS
- Process section:
 - Load chamber #1 (LC1):
Pump and purge cycles to remove atmospheric residuals
 - Load chamber #2 (LC2):
First process gas inlet
 - Heating section: (HC1/HC2/HC3/HC4/HC5)
Five successive heating chambers for the formation of the CIGS_{Se} absorber material including process gas inlet
 - Cooling section: CC1/CC2
Two successive cooling chambers for the cooling of the substrate down to the specified temperature
- Exit chamber (EC):
Pump and purge cycles to remove toxic gases from the process chamber
- Return conveyor section:
Returning the substrate to the handling system and additional cooling in a N₂ atmosphere via forced convection in N₂ cooling stations
- Periphery:
 - Housing
 - Cold traps (selenium absorbers)
 - Oil heating system
 - Pumping system
 - Gas detection system
 - Metrology

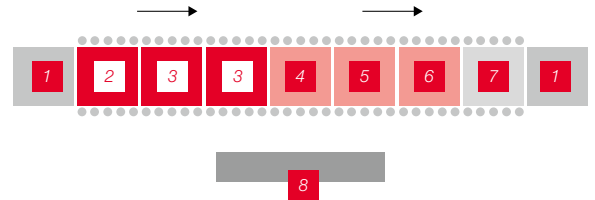
CISARIS – Production System

Technical Data

Material	CIG and CIGSe precursors on glass substrates	
Material Dimensions	approx. 1600 x 650 mm ² (other substrate sizes on request)	
Material Thickness	2 - 3 mm (other thicknesses on request)	
Output	approx. 190.000 substrates/year	(example)
Footprint	36 x 10 m ²	(example)
Cycle Time	< 135 s	(example)
Uptime	> 85 % acc. SEMI E10	
Mechanical Target Yield	> 99,5 %	
Main Voltage	400 V 3AC/PE 50/60 Hz	
Other Required Utilities	cooling water, compressed air, process gases	

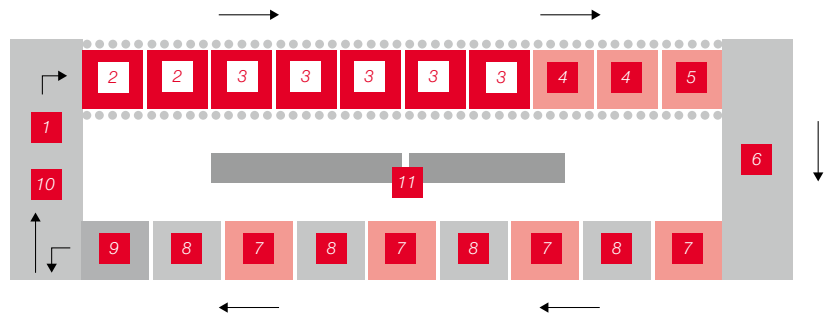
CISARIS Pilot Production Tool – H₂Se/H₂S Concept

- 1 Transport cart for loading/unloading
- 2 Entrance chamber
- 3 Heating/process chamber
- 4 Cooling chamber
- 5 Exit chamber
- 6 Cooling unit
- 7 Atm transition gate
- 8 Electrical cabinets



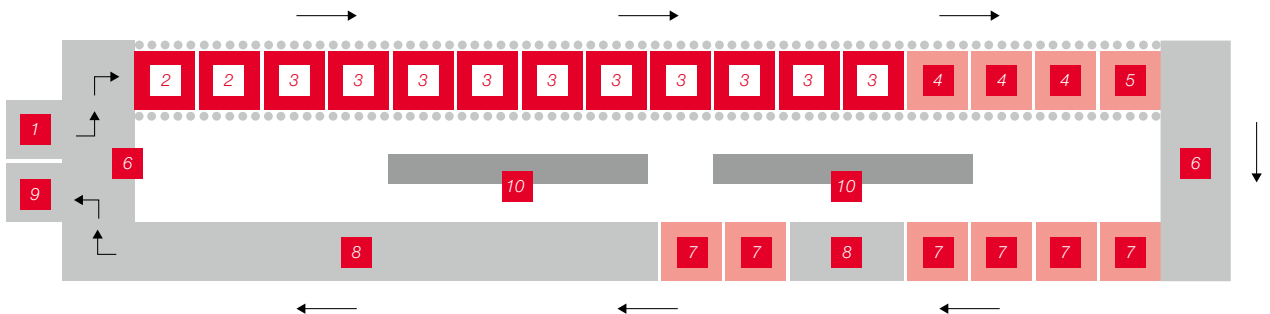
CISARIS Inline Diffusion Furnace for CIGS Solar Cells / approx. 25 MWp Throughput

- 1 Handling station
- 2 Entrance chamber
- 3 Heating chamber
- 4 Cooling chamber
- 5 Exit chamber
- 6 Cross transport
- 7 Cooling units
- 8 Back transport
- 9 Atm transition gate
- 10 Substrate exchange station
- 11 Electrical cabinets



CISARIS Inline Furnace H₂Se/H₂S Concept 60s Tact Time / approx. 50 MWp Throughput

- 1 Loading
- 2 Entrance chamber
- 3 Heating/process chamber
- 4 Cooling chamber
- 5 Exit chamber
- 6 Cross transport
- 7 Cooling units
- 8 Back transport
- 9 Unloading
- 10 Electrical cabinets





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THIN FILM
DEPOSITION

SURFACE
ENGINEERING

THERMAL
PROCESSING

WET
CHEMICAL

SINGULUS TECHNOLOGIES – Innovations for New Technologies

SINGULUS TECHNOLOGIES builds innovative machines and systems for efficient and resource-friendly production processes. SINGULUS TECHNOLOGIES' strategy is to take advantage of its existing core competencies and to expand these further.

The core competencies include vacuum coating, surface processing, wet-chemical and thermal production processes. The company offers machines, which are used worldwide in the solar, semiconductor, medical technology, consumer goods and optical disc sectors. For all of the machines, processes and applications SINGULUS TECHNOLOGIES harnesses its automation and process technology expertise.