SOLARE

Turn-key Production System for Crystalline Cells
SINGULUS TECHNOLOGIES is a supplier of manufacturing solutions and production equipment for the Markets Optical Disc, Semiconductor and Solar. With new machine concepts and manufacturing processes in the crystalline and thin-film solar technology SINGULUS TECHNOLOGIES establishes itself as development partner and equipment supplier for investments in new high-performance solar cell concepts. As market leader for Optical Disc production systems we have gained extensive know-how in vacuum coating, automation and process integration.

SINGULUS TECHNOLOGIES cooperates with cell manufacturers worldwide and develops processes, which improve the efficiency of solar cells and at the same time reduce production costs. Evolutionary improvement in cell concepts like PERC (PERL/PERT), n-type material, IBC cell or heterojunction cells will drive the future of crystalline solar cells.

SINGULUS TECHNOLOGIES offers turn-key production lines for all cell types of today and tomorrow.

**Delivery Range of Products**

→ Standard production line
→ Extended standard production line with selective emitter
→ Production line for PERC like cells and as upgrade
→ PERCEUS production package for PERC cells

For crystalline solar cells SINGULUS TECHNOLOGIES offers:

→ Production of PERC Solar Cells
  → Single side polish etch with LINEA II
  → Rear side passivation with SINGULAR XP
  → PERCEUS Production Package for PERC solar cells

→ Other process applications improving cell performance
  → Complete production lines – SOLARE
  → ICP-PECVD coating equipment – SINGULAR
  → IPA-free wet process equipment – SILEX
  → LINEA II parasitic emitter etching and edge isolation
  → LINEA II isotexture or PSG removal
  → Wet process equipment for poly silicon chunk etching, cleaning & drying – MATERIA
  → Low-cost and high-efficient cleaning process (Upgrade SILEX with Ozone)
01 Wafer Stack Splitting, Loading/Inspection

Silicon solar cells are produced from raw wafers. After unloading from transport boxes, these wafers are tested to ensure that they have the right dimensions and weight and to check for any damage to the edges and surfaces. Good wafers are loaded into the system.

02 Saw Damage Etch (SDE) and Texturing

Batch-type wet benches [SILEX-series] are one choice for cleaning and either alkaline texturing of mono-crystalline or acidic texturing of multi-crystalline wafers. Another option is inline wet chemical processing of the cells with the LINEA machine from STANGL. In this process step any residue and saw damage is removed from the raw wafers and a light trapping structure [texture] is applied by wet chemical process. The etching and rinsing is done automatically in separate baths in an automated sequence.

03 Junction Formation

Today’s standard raw material is positively doped silicon [p-type]. To generate the p-n junction, the wafers are doped with phosphorus. For this process, the substrates are loaded into silicon carbide process boats and are inserted into a tube furnace. Inside the furnace the wafers are exposed to a phosphorus containing gas [POCl3]. At high temperatures of about 900 °C phosphorus atoms diffuse into the wafers. As a result a negatively doped surface layer is created.

04 Phosphorus Silicate Glass Removal/Edge Isolation

For this process step, STANGL offers the SILEX batch and LINEA inline wet processing systems. The phosphorus silicate glass produced as a by-product of the diffusion process is removed in an acid bath. Additionally edge isolation can be realized with the LINEA inline system [PSG-EE].
05 SINGULAR – ICP-PECVD Production Platform for Passivation and Anti-reflection Coatings

SINGULAR ICP-PECVD is a fully automated innovative and modular anti-reflection coating tool for the mass production of crystalline silicon solar cells. In addition, SINGULAR is increasingly being applied for the development of passivation layers for high-efficiency solar cells following conventional and new cell concepts. Thereby, the coating system meets the demands for both, current and future PV cell production.

The SINGULAR system provides an automation module and a coating module. The coating module consists of several customizable vacuum chambers. This high flexibility guarantees a fast and easy transfer of development concepts to industrial production. The innovative SINGULAR tool is based on static inline production, which combines the advantages of inline substrate transport and static processing. It allows the coating of complex layers, such as layer stacks of different materials e.g. AlOx/SiNx. The key feature of the tool is the ICP-PECVD technology. The inductively coupled plasma (ICP) excitation allows ideal control of film properties for various materials such as SiNx, AlOx, SiOx at high deposition rates.

The process variability, the small tool footprint in combination with an excellent total Cost Of Ownership makes SINGULAR ideally suitable for upgrades of existing production lines.

SINGULAR allows developing new manufacturing processes for cell efficiencies above 20 % on proven production platforms.

06/07 Printing/Firing

To extract the electrical power from the solar cell a silver paste contact grid is applied to the front surface of cell by a screen printing process. This creates the characteristic grid pattern on the front of the cell. The back of the cell also receives two silver paste contact strips plus an aluminum layer known as the back surface field. This acts on the electrons as a kind of a mirror. The contacts are burnt into the cell in a hot furnace with around 900 °C. The high temperature causes the silver paste to penetrate into the silicon, thus forming a reliable electrical contact.

08 Testing/Sorting

Tested and classified PV cells need to be sorted and placed safely into storage or transportation boxes. For this purpose the sorter takes over the cells together with their identifier from the upstream testing machine. The cells are picked up by a vacuum suction cup and moved to the respective bins which are predefined by the testing and classification unit. Standard styrofoam boxes are used for taking up the cells. The basic machine allows for sorting into 16 classes. Optionally this may be extended to 32 or 48 classes.
PERCEUS
Production Package for PERC Solar Cells

For the market of silicon solar cells SINGULUS presents a new production solution for rear side passivated silicon solar cells (e.g. PERC; Passivated Emitter and Rear Cell). This solution was developed especially for the upgrade of existing cell production lines. With an additional dielectric coating on the rear side electric and optical efficiency losses of the cells are reduced compared with the traditional cells. In particular, this technology is required for increasingly used very thin wafers in the future.

For the upgrade of a production line three additional production steps, which SINGULUS offers solutions for, are required. Before coating the rear side the cell is smoothed with a wet-chemical polish process in a LINEA II single side etch polish machine. The dielectric passivation layer is emitted in the ICP-PECVD machine SINGULAR. For the rear side contacts through a laser process, SINGULUS is closely cooperating with a partner.

With the integration of these additional production steps into existing manufacturing lines PERC cells with levels of efficiency of up to 20 % can be achieved. In March 2012 the Institute for Solar Energy Research Hameln (ISFH) increased the conversion efficiency of screen-printed silicon solar cells in cooperation with SINGULUS from today’s industry typical 18.5 % to a record value of 20.1 %. This was also confirmed by an independent measurement from the photovoltaics calibration laboratory of the Fraunhofer ISE (CalLab). An improved cell rear side with an ICP-AlOx/SiNy double layer (ICP; “Inductively Coupled Plasma”) enables this progress without “selective emitter” technology.