

UNI-SOLAR OVONIC TECHNOLOGY AND MANUFACTURING PROCESS

United Solar Ovonic has been a pioneer in the development and manufacturing of thin film amorphous silicon PV products. Over the last twenty years, the production capacity has increased from 500 kW to 25 MW per year. In order to obtain high efficiency with good stability, we have pioneered the triple junction cell structure (Fig. 1) where cells of different bandgaps are stacked together. The top cell, which captures the blue photons, uses *a*-Si alloy with an optical gap of ~1.8 eV for the intrinsic (*i*) layer. The *i* layer for the middle cell is an amorphous silicon-germanium (*a*-SiGe) alloy with about 10-15% Ge. The optical gap is ~1.6 eV, which is ideally suited for absorbing the green photons. The bottom cell captures the red and infrared photons and uses an *i* layer of *a*-SiGe alloy with about 40-50% Ge, corresponding to an optical gap of ~1.4 eV. Light that is not absorbed in the cells gets reflected from the silver/zinc oxide (Ag/ZnO) back reflector, which is usually textured to facilitate light trapping. The cells are interconnected by the heavily doped layers that form tunnel junctions between adjacent cells.

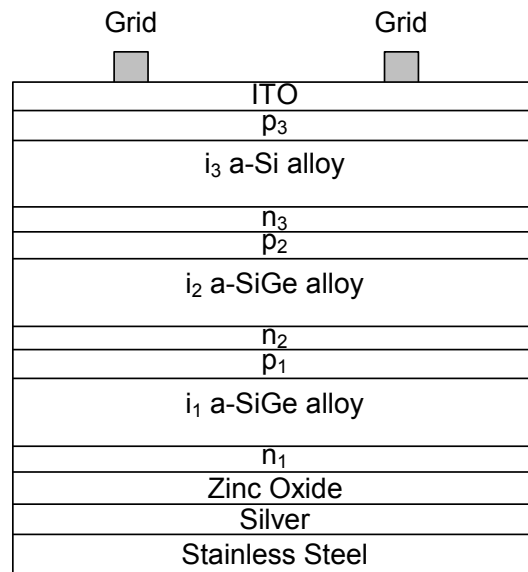


Fig. 1. Schematic of triple-junction structure.

We have developed a roll-to-roll automated process for manufacturing solar cells on stainless steel. Rolls of stainless steel, a mile and a half (2500 m) long, 14 in (36 cm) wide, and 5 mil (125 μm) thick, move in a continuous manner in four machines to complete the solar cell fabrication. The machines are (Fig. 2): 1) The wash machine that washes the web one roll at a time; 2) the back reflector machine that deposits the back reflector by sputtering Al and ZnO on the three rolls of washed webs at a time; 3) the triple junction amorphous silicon alloy processor that deposit the nine layers of *a*-Si and *a*-SiGe alloy layers on six rolls of back reflector coated stainless steels at a time; and 4) the anti-reflection coating machine that deposits indium tin oxide (ITO) on top of the three rolls of stainless steel at a time.

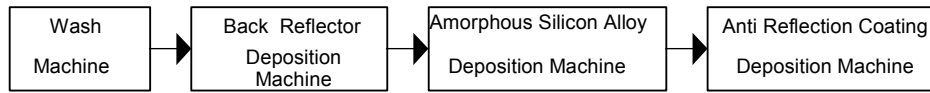


Fig. 2. Schematic of the four production roll-to-roll deposition machines.

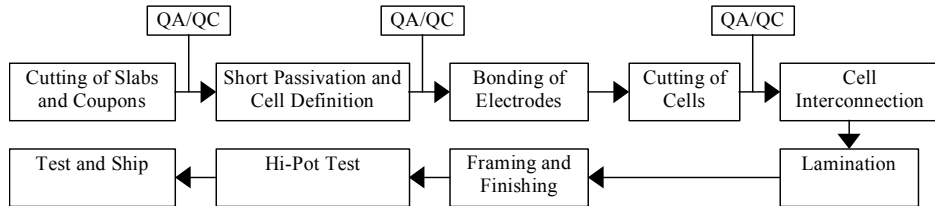


Fig. 3. Module assembly operation.

Both the transport of the web and the process parameters are computer-controlled ensuring reliable and low-cost operation. We use Al back reflector in manufacturing rather than Ag to reduce cost. The coated web is next processed to make a variety of lightweight, flexible and rugged products. The module assembly operation consists of the following steps (Fig. 3). The finished roll of the coated web is first cut into 23.9 cm x 36 cm slabs using a semiautomated press; coupons are also cut during the same operation at preset intervals along the length of the web.

These coupons are processed off-line for QA/QC evaluation. The slabs are then processed to define cell size, passivated to remove shunts and shorts, and tested to ascertain quality. Grid wires and contact pads are next applied, and the slabs are cut into predetermined cell sizes for the various product requirements. The cells are next interconnected and the cell-block laminated to provide protection against outside atmosphere. Depending on the application, frames and junction boxes are added, and the finished modules undergo a hi-pot test and performance measurement under global AM1.5 illumination before they are shipped out.

A schematic diagram of our triple-junction cell processor is shown in Fig. 4. The machine is approximately 90 m long and 3 m tall. There is a vertical central cathode and three webs are transported on each side of the cathode parallel to it at 2 feet (30 cm) a minute. Deposition of nine miles (14.5 km) of solar cells can thus be completed in about 72 hours!

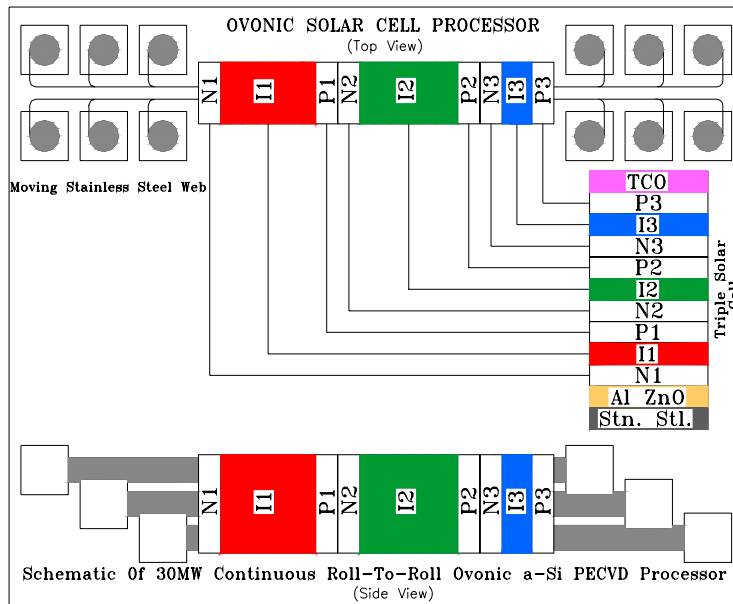


Fig. 4. Amorphous silicon alloy triple-junction cell processor.

The plant is producing a variety of products ranging from small modules to charge batteries in electric appliances to large-scale (500 kW) utility-interconnected application. Use of stainless steel as the substrate and a polymer encapsulant allows the product to be extremely rugged and flexible. Independent studies have also shown that the Uni-Solar products produce more electricity per rated power than those using conventional technology. This is because of the superior performance of the triple-junction products at low light intensity and higher temperature. For more information, please contact Subhendu Guha, squha@uni-solar.com.