Lasers and Solar Cell Manufacturing

By Dick Rieley, Sales Manager, Mid Atlantic and Southeast Regions, Ophir-Spiricon LLC

The Green movement is encouraging the use of energy efficient technologies such as solar cells. This technology has been met with resistance due to its slow return on investment. This is coupled with the challenge of the efficiency of the material used. Reducing the cost of manufacturing solar cells is largely influenced by production efficiencies as well as the type of photovoltaic materials used. Manufacturing efficiencies have been addressed through high speed, nearly fully automated production processes from handling of the panels, deposition of materials, to final packaging. The use of cost effective photovoltaic materials, however, represents a real dilemma. The lower cost deposition materials are less efficient, whereas the higher efficiency materials cost more and can possess carcinogenic elements that are federally controlled.

The solar cell manufacturing community, although addressing more efficient and environmentally safe materials, has concentrated on reducing costs through automated processes. This requires methods that are consistent and reliable. The risk of these operations, however, is that they can produce a large quantity of low cost, high quality material or, just as quickly, they can produce substandard panels.

One aspect of the manufacturing process that is critical is the scribing of the photovoltaic material on the individual cells on the large panels. Lasers have proven to be highly reliable, consistent, and
predictable in their production results. In this high speed manufacturing arena, lasers can easily keep up with production, are silent to use, and typically contribute to a clean manufacturing environment.

**Laser Beam Diagnostics**

However, with all that lasers have to offer and the advantages they can provide, laser beam diagnostics are an essential part of the process, a part that is often overlooked. There are two key diagnostic measurements that are needed to ensure laser consistency from panel to panel: 1) laser beam power, and 2) laser beam diagnostic - size, shape, and intensity.

**Laser Power:** The first measurement - monitor the output power of the laser using a NIST calibrated, laser power meter. Regardless of the quality of the laser beam, if the power is below specification, the scribing process will be rejected. As most laser scribers operate at KHz rates, measuring average power is sufficient. The laser power detector should have an active area twice the size of the laser beam, with a dynamic measurement range from 100mW to 100W, including the NIST calibration at the specific operational wavelength of the process – typically 1064nm, or 532nm. Laser power, when measured on a regular basis, will provide a benchmark of process stability and uniformity.

When a laser power meter is tied into the manufacturing laser consol using USB, automatic and periodic measurements can be taken with pass/fail criteria established for immediate notification of a measurement out of specification.

**Laser Beam Diagnostics:** Along with laser power, the spatial information on the laser beam is equally important to measure and control. Laser beam diagnostics typically involve three measurements; the laser beam size, shape, and intensity. In the production of solar cells, the laser beam is used to scribe (ablate) the deposited layers of photovoltaic material down to the base glass, thereby establishing the individual electrical circuit cells on the panel. With a controlled base line of spatial measurements, the process can be controlled without allowing deviations in the laser beam that could allow residual material in the scribe area potentially causing an electrical short in the overall panel circuit, resulting in a defective panel.

The most typical measurements that are most informative for process control include:

1) The size of the laser beam. The industry standard for beam measurement is 13.5% of Peak \((1/e^2)\). This is useful as the calculation is based on the peak of the beam where the process of ablation is performed and less so on the wings of the beam.
2) The ellipticity (roundness) of the laser beam. Should the beam ellipticity change from round to out-of-round then the ablation pattern will change and the uniformity of the scribe lines will not be consistent, producing of out-of-spec panels.

3) Shape of the overall beam. This can affect the size and effectiveness of the ablation pattern on the glass panel. The above picture is a 3D / 2D image of a typical Top Hat Beam where the energy is uniform across the top portion of the beam pattern. This is quite useful in preparing a uniform scribe of a certain width and depth. Depending upon the process, a Gaussian Beam pattern may be called for as well. In either case a beam diagnostic measurement that compares the Top Hat or Gaussian shape to an ideal fit is a very informative value. Tracking these values to monitor change is essential for close and tight process control of the solar cell laser process.

Ophir-Spiricon LLC

http://www.ophiropt.com/photonics