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One of the facilities of a solar panel manufacturer processes approximately 1,000 panels per shift. Each panel is about 1.5ft x 4ft in size and generates 60W. Their production cost of $2.00 per panel is one of the lowest in the industry.

The production process employs both 532nm and 1064nm scribing lasers, mostly 30W systems. Each panel is scribed by both wavelengths through the process. Their design has each panel placed on a horizontal X-Y table, and run back and forth under a fixed steel yoke where there are a minimum of four beams, scribing four lines simultaneously. The panel ends up with a series of voltage stripes, each about 1” wide and the length of the panel.

The challenge is to split a laser beam into multiple parts that perform equally for the scribing process. In this case, the laser needed to be split into four equal beams and delivered down onto the panel -- 800mm focal length, 60um focal spot, 26uJ per pulse, 8,000hz 25nS pulse width. There are four of these systems.

The panel manufacturer’s current beam diagnostic method is limited to a 2W power meter and a microscope to look at each pulse pattern on the panel during the sampling process. Otherwise, they have to...
wait until functional testing to locate a failure later in the process.

In the 1064nm system, of which they have two, they have designed the overhead yoke to have eight vertical beams – four beams from one laser, and an additional four from a second laser. This allows the same panel to be processed in about 40 seconds, cutting their production time nearly in half. These two systems were: 260uJ, 7,000hz, 25hz, 60um beam, 1064nm. (about 1.86W)

In the above picture of the optical set up, we see optics with blue tape are sourced from the right hand laser and red from the left hand laser. The large X-Y table is below. The 8 brass fittings hold each of the final objective lens.

We conducted several tests to check the focal spot for each of the blue optics (red was not operational). Currently, the manufacturer has no easy method to check the focal spot, its size, or energy density. We used the Spiricon USB-SP620 camera and the LBS300 beam sampler positioned on a lab jack to allow the ability to move the camera back and forth through the focal point. The positioning of the camera and LBS300 can be seen below sitting on the lab jack. We found that once we had the camera aligned for one optic, we could then just move the X-Y table to the right and subsequently test the other three beams easily and with comparative consistency.
In the typical beam profile and measurement, 65 x 78um was the best of the four beams. The spec was thought to be 60um round, but this condition was never seen in any of their four beams.

The other test involved checking the energy per pulse – to see if the energy for each of the 4 beams was identical. We used the Ophir PE-9F with the Pulsar. Again, after setting up the head on the lab jack, so as not to be at focus on the detector, good energy data was obtained. By moving the table on which the detector was positioned, we could move from laser to laser. We ran 180,000 pulses to get a stable measurement. The other beams are visible on the table.
Results

**Focal Spot Measurement:** Through this analysis we demonstrated that where each beam should have the same size and intensity, this was not true. The size of the focal spot across the four beams can range from 66um to 90um. It also showed that after focus, the beam would become oval – an unacceptable condition.

**Energy Measurement:** There was a major discrepancy here, ranging from 260uJ to as low as 160uJ.

Summary
The above-mentioned conditions were suspected by engineering but they had no way of quantifying these issues. And they certainly didn’t have a repeatable, reliable method to measure and correct the condition. The use of our equipment for spatial profiles and energy measurement will be a significant part of the solution to improved process control, and defect management.

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