Scanning Slit Profiler for Characterizing Optical Assemblies

Scanning slits and single element detectors accommodate a wide variety of wavelengths, beam powers, and beam sizes.

by Derrick Peterman, Ph.D., Sales Engineer at **Photon Inc**.
For further information, call (408) 226-1000 or e-mail dpeterman@photon-inc.com.

Optical assemblies are used in an extensive range of technical applications to deliver a laser beam of a certain size, quality, and intensity to a region of space. While different techniques and instruments are available for profiling laser beams, this versatile design uses scanning slits to accommodate a wider variety of wavelengths, beam powers, and beam sizes. In many applications scanning slits eliminate the need for additional optics, such as lenses and attenuators. Attenuation optics can distort a laser's beam and add additional complexity into the measurement. They also prohibit analysis of a beam at its focus because the attenuator increases the optical path length of the beam and may add aberrations. Slit scanners can typically measure down to 4 microns without the use of magnifying lenses.

Because slit scanners measure beams at high powers with little or no attenuation, they are ideal to profile beams used in material processing. Carbon dioxide (CO_2) lasers are widely used in materials processing, and have a 10.6 micron wavelength that cannot be profiled with most cameras. Slit scanners, therefore, provide an alternative means of measuring high-resolution CO_2 lasers with powers up to and exceeding 100 watts.

In this design, the scanning slit beam profiler moves a narrow slit, which is mounted at right angle on a rotating drum, in front of a photo-detector through the beam under analysis (see diagram). Light passing through the slit onto the detector creates a photo-induced current in the detector. The slit acts as a physical attenuator in the scanning slit beam profiler, and the amplification gain on the detector can be set to avoid detector saturation for most beam profiling. A digital encoder precisely measures slit position. The photo-induced current is then plotted as a function of slit position to determine a linear profile of the beam.

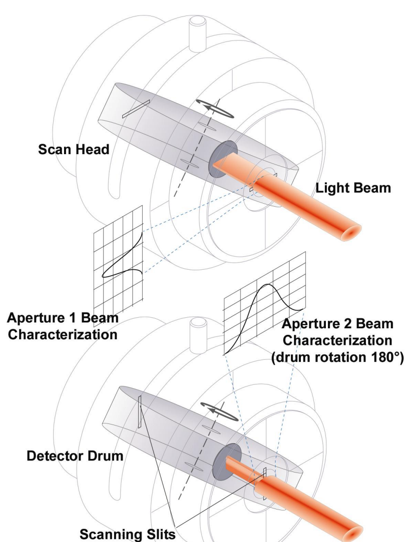
From this linear profile, important spatial information such as beam width, beam position, beam quality, and other characteristics are determined. This technique can accommodate a wide variety of test conditions.

There are no fundamental limitations for using any detector linear in current response. Typically, silicon detectors are used in the slit scanners at visible wavelengths. Germanium detectors are used over the near infrared wavelength range. Pryoelectric detectors are also advantageous for a very broad wavelength range. Pyroelectric detectors are AC-coupled thermal detectors that produce a current directly proportional to the temperature change in the material. They operate over very broadband conditions (190 nm to over 20 microns), allowing for beam measurements over a considerable range. Because these detectors can withstand highly energetic beams, this slit scanner using pyroelectric detectors is ideal for measurement of high-energy lasers used in materials processing and remote sensing, such as the aforementioned CO_2 laser.

The slit scanner's photo-detector can be sampled as the slit passes through the beam at sub-micron increments, allowing sub-micron beam size and position resolution to be obtained. This is important for high precision optical assemblies and to determine high beam collimation. Array detectors, used in cameras, have pixel dimensions ranging from a few microns to a few tens of microns, and therefore are inadequate to generate micron to sub-micron beam size and position resolution. It should be noted, however, that the metallic slit material absorbs light at wavelengths of 1 micron or less. Slit scanners measuring beams at these wavelengths and above powers of 2-3 watts will require some attenuation to avoid damaging the slits.

In addition to small beams and high powers, slit scanners are uniquely suited to measuring very large beams up to 25 mm in diameter. This is because single element detectors of this size are available. The ability to measure over such large areas has advantages in two common optics applications.

First, and seemingly paradoxical, very large beams are required to produce very little beams. Large beams are directed through a large diameter lens with a short focal length to focus the beam to a tight focus. Measuring the large beam prior to the lens allows the beam size at focus to by reliably predicted. A second common application is coupling of a bare laser diode to a lens. Often, the resultant beam at first alignment will emerge from the lens at a wide angle. A large detector is advantageous to find the beam over a large area and provide the data for optimal lens alignment.



The internal workings of a dual-axis BeamScan scan head

This **Beam Profiler Design Relies On Scanning Slits,** rather than attenuation optics, in order to accommodate a wider variety of wavelengths, beam powers, and beam sizes.

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