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Application Note

Measuring Astigmatism the Easy Way

Simple *NanoScan/BeamScan* Measurements of Laser Diode Beams Produces Astigmatism Data

Astigmatism measurements of laser diodes, optical elements, and/or other sources can be made quickly and easily using a NanoScan/BeamScan. For example, by simply focusing the beam from a laser diode onto the profiler and measuring the distance between primary and secondary foci, an indication of source astigmatism is readily obtained. However, since this distance is on the order of 10 microns (μm), longitudinal magnification can be used to accommodate this measurement and reduce potential errors. This method has been used successfully for several laser diode astigmatism measurements.

The beam from the laser diode should be collimated with a lens of rather short focal length in order to reduce unwanted beam-truncation effects. The beam should then be focused with a rather long focal-length lens. This will provide a long depth of focus and thus increase the distance between primary and secondary foci to the millimeter range—well within the range of most laboratory X-Y-Z stages. Figure 1 depicts the basic experimental setup.

By measuring the beam diameter within the of each focal plane, two curves can be generated as shown in Figure 2 (page 2). The distance between each curve's minimum will represent the longitudinally magnified astigmatic distance. The user need only divide this distance by the longitudinal magnification to obtain the astigmatism of the laser diode.

For a typical laser diode measurement where we expect to see approximately 10 μm of astigmatism, the setup might be designed as follows: Choose a longitudinal magnification of about 1000. Since the foci will now be about 10 mm apart, we could like to run the Z-stage (with the NanoScan/BeamScan attached to it) over a span somewhat longer than the expected range of the astigmatism, in this case approximately 12 mm, to produce the curves of Figure 2.

Choose a relatively short focal length lens to begin with. Let's take f_1 = 4.5 mm. Then, since

$$m^2 = \text{long. mag.} = (f_2/f_1)^2 = 1000,$$

so that f2 = 140 mm. So, if we choose a second lens with a focal length of 140 mm, the actual value of m^2 will be 967.9.

The user now need only record and plot beam size versus distance traveled in the Z direction (12 mm in this case). This data will determine the location of both foci.

Then, since ΔZ is the distance between foci, it can be written as

$$\Delta Z = m^2/\Delta L.$$

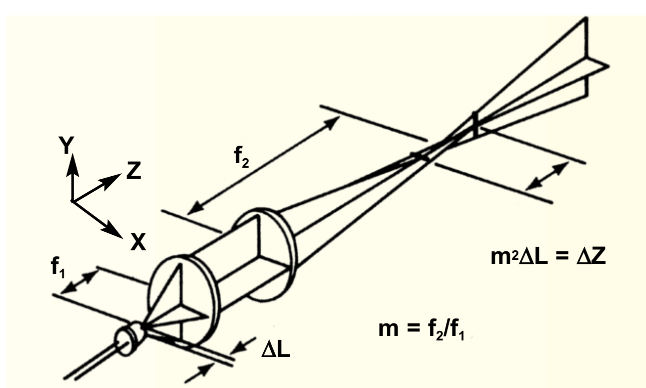

Figure 1. The basic experimental setup for measuring the source astigmatism of a laser diode using a *NanoScan/BeamScan*.

Thus, ΔL, the astigmatic distance of the laser diode under test, will be

$$\Delta L = \Delta Z/m^2$$

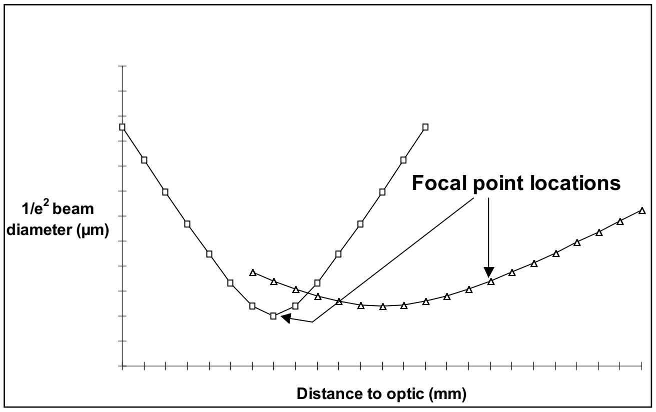

Figure 2. Once the longitudinal magnification of the test setup has been calculated, it is a simple matter to plot the beam diameter as a function of distance to the optical element. From the relative distance between the two minima, the source astigmatism can than be calculated.

Alignment

The laser diode should be positioned with the junction plane either parallel or perpendicular to the optical table. The beam itself should be collimated and focused to the center of the slit in the NanoScan/BeamScan. The NanoScan will then be in reasonable alignment when rotated within 5° of both horizontal and vertical positions. Indeed, with the junction deliberately misaligned by 5° with respect to the scanning-slit orientation, the percentage difference of spot-size measurement will be only about 0.4% as compared to a perfectly aligned beam.

Alternately, a microscope objective can be used as a longitudinal magnifier, but the magnification will have to be measured experimentally, using:

$$1/s' = 1/f - 1/s$$

and $m = s'/s$ = lateral magnification and m^2 = longitudinal magnification. Here, s' is the distance from the objective to the focal plane, s is the distance from the laser output facet to the objective, and f is the effective focal length of the objective.

This measurement technique has been demonstrated as a means of measuring the source astigmatism of a laser diode, using precision optical elements. However, it can easily be extended to other applications. For example, the laser diode could be replaced by a helium-neon (HeNe) laser, with which we could measure off-axis astigmatism of various optical elements.

Computer Control

For production-level testing, this technique can easily be adapted to automated computer control. By interfacing the NanoScan with ActiveX control and using a computer-controlled translation stage, an operator need only do an initial setup. After that, the computer can obtain data, draw graphs, and calculate source or optical-element astigmatism.