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Near-field scanning optical microscopy (NSOM) has directly characterized--to a spatial resolution of 100 nm--the beam profile and astigmatism of a high-power diode laser. Bennett Goldberg, Selim Ünlü, and graduate students William Herzog and Greg Rhodes, from the Center for Photonics Research at Boston University (BU; Boston, MA), use NSOM to study optoelectronic materials and devices. Recently, they extended their work to include analysis of diode laser beams.

In NSOM, a subwavelength aperture formed from a tapered, aluminum-coated, single-mode optical fiber is scanned over the sample. This scanning technique typically provides transverse resolution of l/10 while simultaneously allowing for vertical sectioning by changing the tip-to-sample distance. To measure the beam profile, the NSOM ti¥collected light from the laser. The optical signal collected through the NSOM ti¥was coupled to a photodiode to generate an image (see figure).

The devices investigated were high-power graded-index separate confinement heterojunction (GRINSCH) diode lasers typically used to pum¥erbium-doped fiber amplifiers for long-distance communications. These devices are designed to have a nearly diffraction limited beam profile to achieve high-efficiency coupling into single-mode optical fibers. High-resolution analysis of the beam propagation is crucial not only in optimizing the diode laser structure but also for the optical design of fiber coupling.

Conventional far-field characterization of diode lasers involves scanning slit systems that use auxiliary optics to collimate the diode output. Although such systems are simple to use and reliable, far-field diagnostic systems are only able to measure the divergence angle and astigmatism of the diode laser. Scanning knife-edge beam profilers are incapable of placing the waist minimum and transverse beam position relative to the physical device structure.

Application of NSOM to laser diode characterization provides high lateral resolution, high-resolution vertical sectioning of the mode intensity, and correlation of the optical field and the laser-diode structure. By directly measuring the optical field intensity in the transverse plane at the facet and as a function of distance from the facet, the researchers were able to measure the beam divergence and astigmatism, as well as observe that the laser was self-focusing at 3 µm outside the laser facet.1

While NSOM has slowly become more common in research laboratories for sub-wavelength imaging and spectroscopy, the team at BU believes the application of NSOM to diode-laser characterization will proceed at a much quicker pace. Ünlü says that only a small fraction of the data for this type of characterization actually involved operating the microscope under shear-force feedback (necessary for tracking the surface at heights less than 10 nm). Most of the data for characterizing the beam propagation of a laser diode are collected a few microns above the laser facet. Herzog says, "A few microns is a country mile in this field.`` The researchers expect to see NSOM used in optical characterization of diode lasers in the near future.

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