

results in the collection of 99-percent-pure LOX in the reboiler. The nitrogen-rich vapor is vented as waste at the top of the column. The structured packing enables the column operation to be insensitive to tilt angles of up to 20°, with respect to the local gravity vector. We

are currently working to further miniaturize the distillation technology to provide a portable, lightweight, and low-power source of high-purity nitrogen and oxygen for other applications.

*This work was done by Jay C. Rozzi of Create, Inc., for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17593-1.*

## Even Illumination From Fiber-Optic-Coupled Laser Diodes

Emerging light beams would be shaped by diffractive fiber-optic tips.

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A method of equipping fiber-optic-coupled laser diodes to evenly illuminate specified fields of view has been proposed. The essence of the method is to shape the tips of the optical fibers into suitably designed diffractive optical elements. One of the main benefits afforded by the method would be more nearly complete utilization of the available light.

As shown in Figure 1, the light beam emerging from the flat tip of an optical fiber coupled to a laser diode has a Gaussian distribution of intensity across a circular cross section, whereas what is typically desired is to concentrate the light into a beam characterized by a “top-hat” distribution (even illumination in a specified field of view, zero illumination outside the field of view). In order to obtain an acceptably close approximation of even illumination in the field of view, the Gaussian beam must be significantly wider, so that much or most of the light is wasted outside the field of view. A conventional lens can be used to partially shape the beam, but the beam does not lose its basic Gaussian character; this is true whether the lens is placed at a focal distance from the tip, in contact with the tip, or formed onto the tip surface as an integral part of the optical fiber.

Diffractive optics is a relatively new field of optics in which laser beams are shaped by use of diffraction instead of refraction. There exist ways to produce diffractive lens elements that shape laser beams into desired arbitrary cross sections (for example, the arrow shapes of the beams generated by many laser pointers). In a fiber-optic-coupled laser diode according to the proposal, the optical fiber would be tipped with a diffractive surface such that the diffraction pattern imposed on light leaving the fiber would, at a desired distance from the tip, concentrate the beam at nearly even intensity into a cross section of specified shape.

Usually, the desired illuminated area would be rectangular or circular, but in principle, the diffractive surface could be designed to shape the beam to almost any specified cross section. In one version of the proposal, the diffractive shape would be etched directly onto the initially flat tip surface of the fiber. In another version, the diffractive surface would be molded onto a transparent piece of plastic that would be bonded to the tip, the mold having been previously etched or otherwise formed to the diffractive shape.

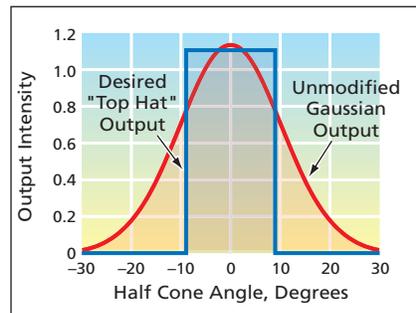


Figure 1. The Distribution of Laser Light emerging from an optical fiber is typically Gaussian, whereas often a “top hat” distribution is desired.

A diffractive fiber-tip surface that would function in this way has not yet been designed. However, it has been estimated, for example, that such a pattern on the tip of an optical fiber of 110- $\mu\text{m}$  diameter would consist of about 300 prisms of various heights resembling buildings on 5- $\mu\text{m}$ -square city blocks (see Figure 2), fabricated by etching the square areas to different depths from an initial flat tip surface. A small developmental problem is posed by the difficulty of etching such a pattern.

As in the case of any diffractive optic, some light would pass through undiffracted; hence, the output light pattern that would be mostly the desired pattern with a slight superimposed Gaussian pattern.

*This work was done by Richard T. Howard of Marshall Space Flight Center. Further information is contained in a TSP (see page 1).*

*This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31843-1.*

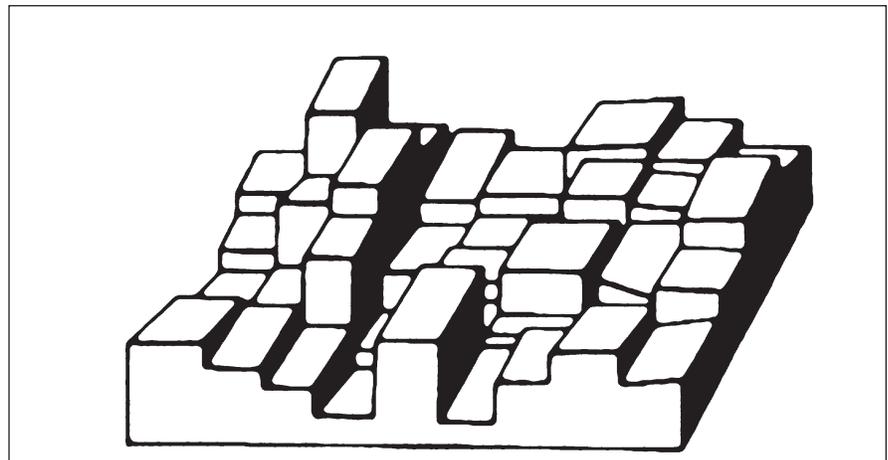


Figure 2. This Diffractive Optic was formed in plastic. Optical performance is affected by the widths and depths of steps and the sharpness of edges. Although a rectangular floor plan is shown in this example, the floor plan for application to the tip of a round optical fiber would be circular, even if the optic were to be used to illuminate a rectangular area.