PHOTONICS SPECTRA

Single-Crystal Nd:YVO_4 Fiber Exhibits Good Laser Parameters

Neodymium-doped vanadates have proved very successful materials for miniature diode-pumped lasers because of their high optical absorption at the 808-nm diode wavelength and their high cross section for stimulated emission at 1064 and 1342 nm. Vanadates, like most laser crystals, usually are grown from a melt in a crucible, and their high melting temperature (~1850 °C) can limit crucible lifetime and can lead to contamination of the melt.

The need for a crucible can be eliminated by the floating-zone method (see *Photonics Spectra*, January 2004, page 40), but researchers at the Universidade de São Paulo in Brazil have fabricated single-crystal Nd:YVO4 fibers without a crucible using a laser-heated pedestal growth technique that also enables crystals to be grown up to 10 times faster than the crucible processes. In what they believe are the first laser experiments with a single-crystal fiber, they have found that its performance is nearly as good as that of conventional Nd:YVO4 lasers that are based on bulk crystals. Growth of optical-quality, single-crystal fibers is challenging, mainly because oxygen deficiencies cause valence changes of vanadium ions during growth, resulting in the creation of dark, optically lossy zones. The group overcame this problem by growing the crystal in a chamber in the presence of five to 10 atmospheres of oxygen (Figure 1)

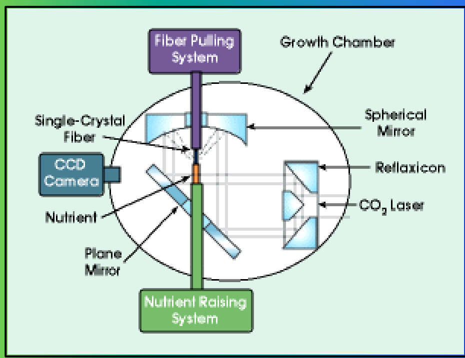

Figure 1: A laser-heated pedestal growth technique enables the production of Nd:YVO4 fibers without a crucible. High-quality, single-crystal fibers were grown in the presence of five to 10 atmospheres of oxygen.

Laser-heated pedestal growth is similar to the floating-zone technique in that both utilize surface tension to support the molten zone between the feedstock and the crystalline material. In this process, the heat of a CO_2 laser melts the tip of the feedstock ("Nutrient Raising System" in Figure 1), and a seed crystal is contacted to the melt. The seed and the feedstock are then raised, bringing new feedstock into the focus of the laser and allowing the single-crystal material above the focus to cool and solidify

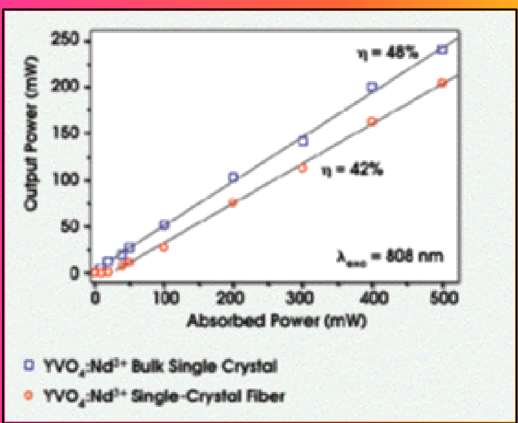

Figure 2: Performance from the single-crystal Nd:YVO_4 fiber is nearly as good as that from a bulk Nd:YVO_4 crystal, suggesting that single-crystal fibers are good candidates for miniature diode-pumped lasers.

Excited-state absorption -- the absorption of a pump photon by an ion in the upper laser level, which is boosted to an even higher level -- can be a significant problem for solid-state lasers, both because it wastes a pump photon and because it removes an atom from the population inversion. The scientists analyzed their single-crystal Nd:YVO_4 samples spectroscopically and concluded that excited-state absorption is negligible at the 1.064-μm transition but that it can seriously impede the 1.342-μm transition. But because the proof of the pudding is in the laser results, they cut one of their 400-μm-diameter fibers to a 1.0-mm length and placed it between 1.064-μm laser mirrors. One was a 50-mm-radius-of-curvature output mirror whose 1.064-μm transmission was 5 percent, and the other was a maximum reflector coated directly on the end of the fiber. They pumped the fiber longitudinally through the maximum reflector with a Ti:sapphire laser at 808 nm, although a diode laser could have been used. They also placed a bulk Nd:YVO_4 crystal in the same resonator for comparison and observed nearly identical results (Figure 2).

The researchers concluded that single-crystal fibers are good candidates for the construction of compact diode-pumped lasers.

Photonics Research February 2004 by Breck Hitz

Optics Letters, Jan. 1, 2004, pp. 59-61