Total reflection resonator with hole coupling

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Total internal reflecting surfaces have been proposed as regenerative structures for solid-state lasers; the laser energy is extracted from the resonator through frustrated total reflection by a coupling prism.[1,2] Instead of using frustrated total reflection to extract the energy, we found the energy can be extracted through a hole on the tip of the total reflecting surface.

In this experiment, we polished the two ends of a Nd:Yag laser rod into 90° cones with one cone tip polished into a small flat surface (1 mm in diam, with no intention of optimizing the output coupling) as shown in Fig. 1. The 90° cones from the total internal reflecting surfaces and the small flat surface are used as an energy output port. Intuitively, this structure is more or less similar to the hole coupling used in CO_2 lasers.

This Nd:Yag laser rod, 69 mm in length and 5 mm in diam, with 1.2% Nd^{+3} concentration, is then put into a gold-coated circular cavity and pumped by a pulsed xenon flashlamp. The typical discharge condition was a capacity of 50 μF and 600 V. The output energy detected by a *P-I-N* photodiode (with a RG780 1.06-μm filter in front of the detector) is shown in Fig. 2. The oscilloscope traces show a sudden rise of output energy in Fig. 2, which confirms that laser oscillation does occur in such a structure. No such oscillation has been observed when we did not polish the cone surfaces under otherwise identical pumping conditions.

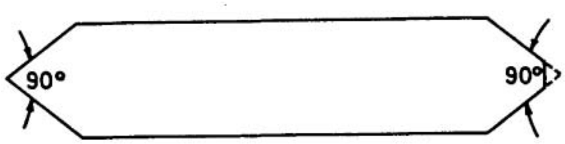

Fig. 1. Schematic diagram of a solid-state laser using total internal reflecting surfaces as resonator and with hole coupling.

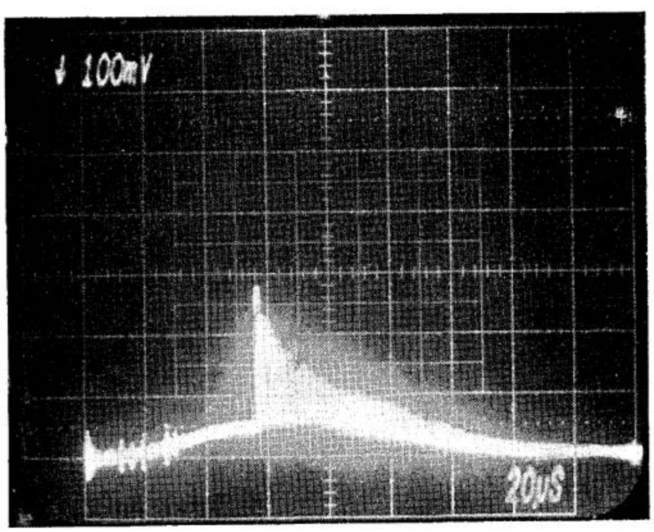

Fig. 2. Pulsed output of Nd:Yag laser with total internal reflecting surfaces using hole coupling. This picture shows ~58-μsec delay of laser pulse.

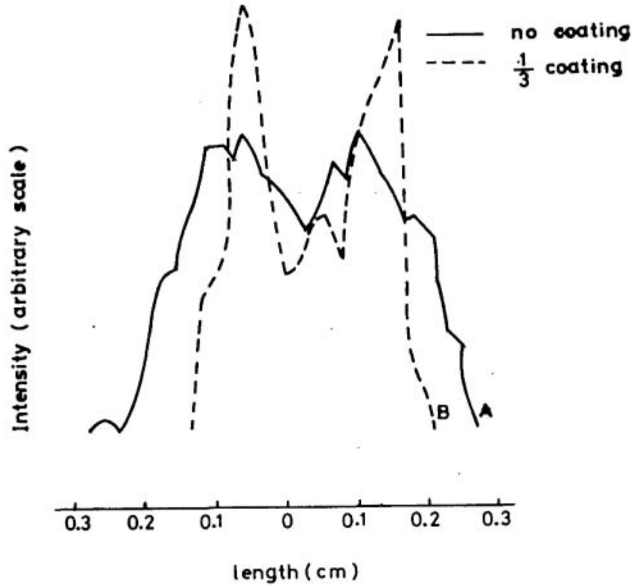

Fig. 3. Near-field spatial distribution of the time-integrated output laser beam.

The spatial distribution of the near-field laser beam can be altered by increasing the scattering loss of the outside ring of the cone surfaces as shown in Fig. 3. Curve *A* represents the output laser beam when the cone surfaces are clean, while curve *B* represents the output laser beam when one-third of the cone surfaces is coated with dust particles. The output power is typically on the order of 70 mJ/pulse.

Since no dissipative metallic and multilayer dielectric coatings are required, the threshold pumping power and hence heating effect are reduced to minimum as discussed in Ref. 1. This is because a fine-polished total-reflection surface has minimum loss compared with that of dissipative coatings. In addition to the above-mentioned advantages, this structure is expected to be more useful in field operation where vibration and thermal-induced mirror misalignment problems may be serious. This holds because no external components are required, and hence no resonator alignment problem exists after the laser rod is fabricated.

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References

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