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CFJ1 Acousto-optically induced single-mode and Q-switched operation of a miniature diode-pumped Nd:YLF ring laser

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When forced to operate as unidirectional devices, many solid-state ring lasers can yield a reliable single mode output. Unidirectional operation is possible only if a sufficiently large loss-difference exists between the two counter-propagating beams. This is generally achieved by incorporating a Faraday isolator in the ring cavity. In order to minimize cavity losses, in low gain diode-pumped solid-state lasers, it is convenient to make use of the small Faraday effect which occurs in the laser medium itself.[1] Unfortunately, this technique may not be well suited to those laser media having a very small Verdet constant at the laser operating wavelength, or for those materials, for example, Nd:YLF, having birefringence.

An alternative technique for enforcing unidirectional operation, recently demonstrated in the case of dye[2] and Ti:sapphire[3] ring lasers, involves using the acousto-optic effect. In this paper we show that both effective and extremely reliable single frequency cw and Q-switched operation can be achieved for a miniature diode-pumped Nd:YLF ring laser using an intracavity acousto-optic modulator.

The ring laser design adopted is of the rhomb-type[4] and is shown in Fig. 1. It consists of only three optical components, where only one component, a Brewster-angled rhomb-shaped acousto-optic Q-switch distinguishes it from a simple standing-wave resonator. This fact renders the laser extremely easy to align, and in addition, it can have extremely low cavity losses. The Q-switch is fabricated from lead molybdate and has its electrodes configured so that a diffraction-loss can be obtained along both paths through the rhomb.

For cw single frequency operation a low power radio-frequency signal is applied to the Q-switch continuously at a level which is just sufficient to enforce unidirectional operation. Since the net diffraction loss which results from this is very low, there is only a very slight reduction in the total laser output power. Under these operating conditions and when pumped by two high brightness broad-stripe 500 mW diodes (supplied by STC Optical Devices), cw single frequency operation could be achieved at either 1.047 μm or 1.053 μm, depending on the orientation of the Nd:YLF rod. In both cases it was confirmed that operation was single frequency up to the maximum available pump power of 1 W, which yielded maximum laser output powers of 340 mW and 270 mW, respectively.

For an arrangement which is not optimized, Q-switching resulted in single mode pulse energies of 50 μJ and 11 ns duration for operation at 1.047 μm, and pulse energies of 70 μJ and 11 ns duration for operation at 1.053 μm. In the latter case, this corresponds to a peak power of ~6 kW, with a pulse fluctuation in peak power which was less than 1% up to 500 Hz repetition rate.

We believe that this technique for unidirectional operation offers many advantages over methods which use the Faraday effect. When used in conjunction with the low loss resonator design described, the technique offers a general design for single frequency cw or Q-switched lasers of great simplicity and with applicability to a wide range of laser materials operating over a wide spectral range.

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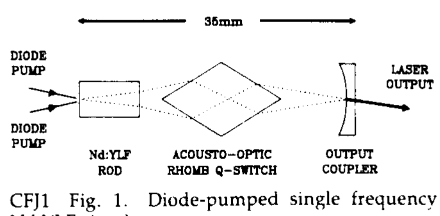

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