Monday MORNING
May 11, 1992 CMI
CONVENTION CENTER ROOM B4

10:30 am Compact Diode-Pumped Laser Designs

Renny Arthur Fields, *Aerospace Corp., Presider*

10:30 am

CMI1 Explanation of the mechanism for acoustooptically induced unidirectional operation of a ring laser

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Unidirectional and hence single frequency operation of a ring laser is generally achieved using an intracavity Faraday isolator. An alternative technique, demonstrated recently for Nd:YAG,[1] dye,[2] and Ti:sapphire ring lasers,[3] makes use of the acousto-optic (AO) effect. This technique offers significant advantages over the Faraday isolator approach, particularly for miniature solid-state lasers,[4-6] since only one extra component is required. Also, the technique does not rely on polarization discrimination and is therefore well suited for use in lasers containing birefringent elements, for example, laser media and frequency doublers. Additionally, an AO device offers the possibility of Q-switching the laser output to obtain higher peak powers. To the best of our knowledge, an adequate explanation for the non-reciprocal behavior of a traveling-wave AO Q-switch has not yet been reported. A knowledge of the mechanism is nevertheless important if better optimized devices yielding higher loss-differences are to be made.

In this paper we offer an explanation for the non-reciprocal behavior of a traveling-wave AO Q-switch and provide experimental evidence to support it. Our explanation relies on the fact that when light is reflected from a moving surface, the angles of incidence and reflection are no longer identical. This situation occurs in a traveling-wave AO Q-switch. Laser radiation incident on the Q-switch is reflected from moving refractive-index variations caused by the acoustic waves traveling through the medium. When the device is tilted so that all the reflected contributions are in phase, the Bragg condition is satisfied and the amount of reflected light is at a maximum. A consequence of the traveling grating, however, is that the Bragg condition is now satisfied at different angles of incidence for the counterpropagating beams, and as a result the two beams generally experience different diffraction losses. The difference $\Delta\theta$ in the angles of incidence at the Bragg condition, is given (in air) by $\Delta\theta = 2n^2v_s/c$, where v_s is the velocity of sound in the Q-switch material and n is its refractive index. In our case the Q-switch was fabricated from lead molybdate, for which the angular difference is calculated to be 0.0076°. Although at first sight this angle appears to be very small, it proves to be large enough to cause counterpropagating beams to experience significantly different diffraction losses. Indeed, under certain circumstances the loss-difference achievable can be >10% of the actual diffraction loss. The ratio of the loss-difference to the diffraction loss depends on the Q-switch design, its orientation, and the laser beam dimensions.

To provide experimental proof of the proposed mechanism, measurements of the loss-difference in a diode-pumped Nd:YAG ring laser and measurements of the angular difference in a standing-wave resonator have been made. In both cases good agreement is found between measured and predicted values, confirming the validity of the model.

One important feature of the model is that it suggests that the requirements for efficient unidirectional operation and Q-switched operation are not necessarily the same. This has implications for the optimum Q-switch design and choice of AO material. Now that a quantitative understanding of the nonreciprocal behavior of traveling-wave AO Q-switches is available, optimized design of AO Q-switches can be made to meet the requirements for both enforcement of unidirectional operation and Q-switching.

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