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Notes and Lines

Laser Action of *M* Centers in Lithium Fluoride

ROBERT W. BOYD, JAMES F. OWEN, AND KENNETH J. TEEGARDEN

We report the observation of room-temperature laser action at 700 nm in lithium fluoride containing *M* centers. LiF single crystals were pumped with a nitrogen-laser-pumped dye laser operating at 450 nm. Laser action has previously been reported in liquid-nitrogen-cooled alkali halides containing F_A(II) [1]–[3], F_2^+ [4], [5], F_2^- [5], and F_B(II) [6] color centers.

The *M* center (also referred to as the F_2 center) consists of two electrons trapped by two adjacent anion vacancies. In LiF, *M* centers give rise to broad absorption and emission bands at 450 and 700 nm, respectively [7]. The 200-nm width of the emission band may provide a system continuously tunable from 600 to 800 nm. Heavier alkali halides, which have *M*-band emission at longer wavelengths, are potential candidates for *M*-center lasers operating out to 1.4 μm.

Single crystals grown by the Harshaw Chemical Company, in which color centers were created by cobalt 60 γ-irradiation, are being used in the *M*-center laser. The concentration of *M* centers is typically 2×10^{16}/cm.[3] The optical resonator for the laser is a two-mirror cavity of nearly hemispherical configuration consisting of a plane and a 5-cm-radius end mirror separated by 4.5 cm. The end-mirror reflectivities of 99 ± 1 percent at 700 nm were chosen to provide a high-Q cavity and thus minimize laser threshold at the possible expense of output power. The LiF crystal is coaxially pumped along the [100] axis at normal incidence to cleaved, but unpolished, surfaces. The path length through the crystal is approximately 1 cm. The pump is a nitrogen-laser-pumped, Coumarin-2 dye laser which produces 30 kW of peak power in 6 ns pulses. The pump beam is focused into the center of the lithium fluoride crystal by a 50-cm focal length lens.

We have measured the output energy of the *M*-center laser to be 0.5 μJ per pulse. The pulse length is 4 ns, slightly shorter than the duration of the excitation. The peak output power is thus on the order of 100 W. Since no dispersive elements are used in our cavity, the laser wavelength and bandwidth are determined by the wavelength dependence of the *M*-center gain coefficient. The laser output extends from 680 to 720 nm and peaks at 700 nm. One should be able to narrow this line breadth significantly by the use of a three-mirror cavity [8] containing dispersive elements.

A bleaching phenomenon is found to limit laser action to about 70 pulses at any one position within the crystal. The nature of the bleaching mechanism is not presently understood, but could be due to transitions to long-lived triplet states or conversion of *M* centers to other stable color centers. Continuous-wave laser action should be possible if this bleaching mechanism can be eliminated. The *M*-center laser would then be an important complement to current dye lasers since the former is inherently capable of significantly greater frequency stability.

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The authors are with the Institute of Optics, University of Rochester, Rochester, NY 14627.

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Note added in proof: It has come to the authors' attention that *M*-center laser action in LiF has been reported by Gusev, Konoplin, and Marennikov (*Sov. J. Quantum Electron.*, vol. 7, pp. 1157–1158, 1977). These authors make no mention of the temperature of their LiF crystal, nor do they report bleaching in their system.

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Correction to "Oscillation Properties of Anisotropic Lasers"

KENJU OTSUKA

In the above paper,[1] (27) should have read

$$w > \frac{2R_e^2(1+A) - 2R_e(2+A) + 1}{R_e(1-2R_e)} \equiv w_c. \tag{27}$$

In the caption of Fig. 15, (a) and (b) should have shown y-polarization and x-polarization, respectively.

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The author is with the Musashino Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation, Tokyo, Japan.

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