Spontaneous and Stimulated Emission Characteristics of the Excimer Xe_2Br

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PACS: 42.60

Broadband emissions from triatomic rare gas halides have been investigated recently in an effort to develop new tunable excimer lasers in the visible and UV wavelength regions. Because of the large bandwidth and long radiative lifetime of these transitions, the gain of trimers is considerably less than for dimers. Laser action as so far been reported for two trimers, Xe_2Cl [1] and Kr_2F [2, 3] with emission wavelengths centered at 520 and 436 nm, respectively. In this paper the first experimental demonstration of stimulated emission in Xe_2Br, at 445 ± 35 nm, from electron beam-excited high pressure mixtures of argon or neon with xenon and one of several bromine donors. Details of Xe_2Br kinetics, based on fluorescence measurements, will also be presented.

All experimental studies were carried out with the apparatus described in [1, 2]. Excitation was achieved by short, intense electron beam pulses (1 MeV, 15 kA, and 10 ns) from a Physics International Pulsrad 110 accelerator. The electron beam pump pulses were injected transversely through a 50 μm titanium foil over a 10 cm^2 area into a stainless steel cell filled with the rare gas halogen mixtures. The spectral and temporal spontaneous and stimulated emission characteristics were measured using a PAR OMA1 optical multichannel analyzer and a Tektronix 7912 transient digitizer.

Electron beam excitation of Ar/Xe/Bromine donor mixtures induced electronic transitions identified as XeBr(B→X), Br_2, and Xe_2Br. Fluorescence measurements and procedures developed for the study of Xe_2Cl production and quenching [4] were used to determine the kinetic processes leading to the formation of Xe_2Br^*. Several bromine donors were evaluated: CBr_4 and $CHBr_3$ produced the highest fluorescence yield. Three-body collisional quenching of XeBr* has been identified as the major formation mechanism. The third order rate constant for this reaction has been measured to be $k_1 = 3 \times 10^{-31}$ $cm^6 s^{-1}$. In addition, quenching rates for collisional de-excitation of Xe_2Br^* by the bromine donors, Xe and Ar, have also been determined to be 5.6×10^{-10} $cm^3 s^{-1}$ (for $CHBr_3$), 2.4×10^{-13} $cm^3 s^{-1}$ and 0.4×10^{-13} $cm^3 s^{-1}$, respectively. The radiative lifetime has been measured as 235 ± 30 ns. The stimulated emission cross-section was calculated to be 0.3×10^{-17} cm^2; with an estimated excited state density of 5×10^{15} cm^{-3} a gain of ~ 0.01 cm^{-1} is expected. This compares with a gain for Xe_2Cl of 0.03 cm^{-1} [5, 6].

A time-integrated stimulated emission spectrum for an optimized mixture of 6 atm Ar, 50 Torr xenon and 0.5 Torr $CHBr_3$ is shown in Fig. 1 obtained with an intracell resonator of 2 cm effective length, ($R_1 \geqq 99\%$, $r_1 = 0.5$ m, $R_2 = 98\%$, $r = \infty$). Misalignment of the laser cavity mirrors caused a loss of observable output signal. The presence of severe Xe_2^+ and Xe_2^* absorption [7] centered at 390 nm is particularly evident when using high xenon pressures and long resonator lengths. The structure in the emission spectrum is the result of enhanced intracavity absorption from excited atomic species as in the case of the XeF(C→A) and Xe_2Cl lasers [5]. A significant change in the xenon pressure dependence for Xe_2Br spontaneous and stimulated emission intensity is depicted in Fig. 2.

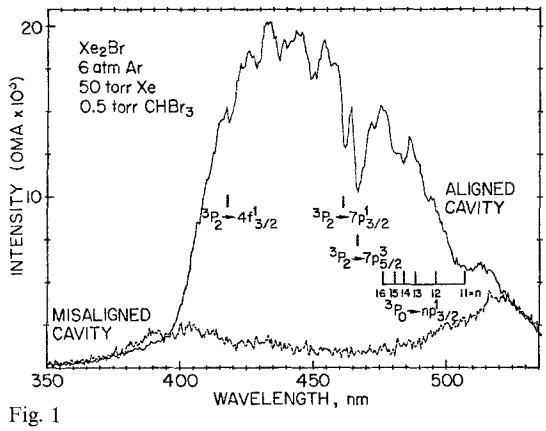

Fig. 1

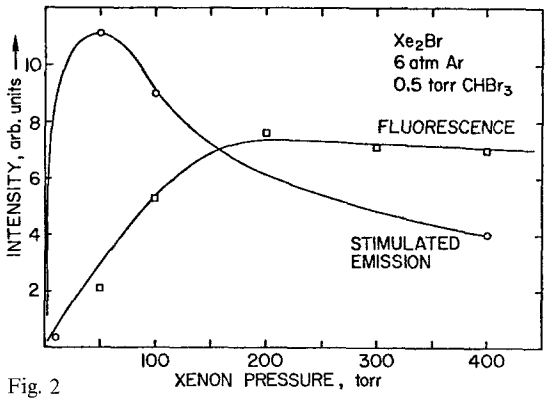

Fig. 2

In conclusion, the formation and quenching kinetics, as well as the optical emission characteristics of Xe_2Br^* has been investigated.

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