METAL VAPOR EXCIMER LASER

QUARTERLY PROGRESS REPORT
for Period May 1, 1979 - July 30, 1979

MASTER

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AVCO EVERETT RESEARCH LABORATORY, INC.
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October 1979

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REA

ABSTRACT

The formation efficiency for discharge pumping HgCd^* has been measured as 0.5 indicating near to unity branching of HgCd^* formation. Gain/absorption measurements show what appears to be intrinsic absorption over the HgCd^* emission band.

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I. INTRODUCTION

Absolute HgCd* fluorescence intensity measurements over the HgCd* emission band and the HgCd* spectrum over the fluorescence band have allowed us to calculate the HgCd* formation efficiency.

II. HgCd* FORMATION EFFICIENCY

The efficiency of coupling the electrical discharge energy, $i \times V \times \tau$, into energy in HgCd* fluorescence is given by

$$\eta = \frac{[\text{HgCd}^*] h\nu_{\text{HgCd}^*} A \ell}{i V \tau} \quad (1)$$

where

$$[\text{HgCd}^*] = \text{HgCd}^* \text{ density } (\sim 10^{16} \text{ cm}^{-3})$$

$$h\nu_{\text{HgCd}^*} = 2.6 \text{ eV } (470 \text{ nm})$$

$$A = \text{geometric cross section of discharge } (1.25 \text{ cm}^2)$$

$$\ell = \text{discharge path length } (40 \text{ cm})$$

$$i = \text{discharge current } (50-100 \text{ A})$$

$$V = \text{discharge voltage } (10-15 \text{ kV})$$

$$\tau = \text{discharge pulse duration } (\sim 1.5 \text{ } \mu\text{sec})$$

The determination of $[\text{HgCd}^*]$ was reported on in the last quarterly report. Operating under the above conditions, we typically measure $[\text{HgCd}^*] \sim 10^{16} \text{ cm}^{-3}$. Substituting the measured above parameters, one finds that the fluorescence efficiency for producing HgCd* is $\eta \sim 0.5$.

The dominant formation channel for the HgCd* in a Cd/Hg/Ne mixed metal discharge is

Thus, the quantum efficiency for producing an HgCd* goes as the ratio

$$\eta_{QE} = \frac{E(\text{HgCd}^*)}{E(\text{Cd}^*)} = \frac{2.6 \text{ eV}}{3.7 \text{ eV}} = 0.7 \quad (5)$$

Our computer codes indicate that up to ~ 80% of the discharge energy goes into Cd* so one would expect that the maximum formation efficiency for HgCd* is (0.7) x (~ 0.8) ~ 0.5. These measurements, therefore, indicate unity branching into HgCd*.

The high efficiency for discharge pumping HgCd* combined with the low electron quenching rates (as discussed in the last quarterly report) made this system a promising candidate for a scalable laser for fusion. Since there has been some controversy associated with the gain/absorption measurements for optically pumped HgCd*, we undertook to repeat these measurements for discharge pumped HgCd*.

III. HgCd* GAIN/ABSORPTION MEASUREMENTS

Figure 1 is a schematic diagram of the gain/absorption apparatus. This is a standard gain/absorption setup in which we used a cw Ar ion tunable laser which has five lines that overlap the HgCd* emission continuum.

A typical measurement for a Cd/Hg/Ne mixture, 4.5 torr/110 torr/414 torr at 517 nm is shown in Figure 2. The lower oscillogram shows the I/V characteristics of the discharge. The $\sim 1.5 \mu\text{sec}$ pulse is preionized by an $\sim 200 \text{ A}$ Febetron pulse occurring $\sim 100 \text{ nsec}$ before the discharge. The discharge voltage is $\sim 13 \text{ kV}$ and the discharge current rises during the pulse from $\sim 50 \text{ A}$ to $\sim 100 \text{ A}$ at which point a crowbar is applied to the voltage. Had the pulse been extended, a volumetric breakdown of the discharge would have occurred. The upper oscillogram shows two traces. The top trace is of the HgCd* emission as monitored by a photodiode/filter system with the filter centered at 470 nm and passing $\sim 1/3$ of the HgCd* emission. Note that the HgCd* emission rises with the discharge pulse, peaking where the crowbar is applied. The emission then decays in the afterglow with a $\sim 2 \mu\text{sec}$ lifetime. The absorption is shown on the bottom trace of the upper figure. The absorption increases with increasing [HgCd*] formation and is seen to decay with the HgCd* decay. Similar measurements were made at various wavelength

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Figure 1 Schematic of Gain/Absorption Measurement

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Figure 2 Gain/Absorption Measurement in HgCd* for Cd/Hg/Ne:
4.5 Torr/110 Torr/414 Torr Mixture at 517 nm

across the HgCd^* band and the results are plotted in Figure 3. The absorption increases toward the blue and follows the $[\text{HgCd}^*]$ so closely that it would seem to be intrinsic to the exciplex and probably arises from the HgCd^* excited level. These results are similar to those reported by West et al.⁽¹⁾ and to the more recent work of McGeoch.⁽²⁾

Figure 3 Measured Absorption in HgCd* for 40 cm Path

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2. McGeoch, M.W., private communication.

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