METAL VAPOR EXCIMER LASER

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

A. Mandl and D. Klimek

AVCO EVERETT RESEARCH LABORATORY, INC.
a Subsidiary of Avco Corporation
Everett, Massachusetts 02149

October 1979

prepared for
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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 calculated 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

\[
\eta = \frac{[\text{HgCd*}] \ h\nu_{\text{HgCd*}} \ A \ell}{i \ V \ \tau} \tag{1}
\]

where

\( [\text{HgCd*}] = \text{HgCd* density} \ (\sim 10^{16} \text{ cm}^{-3}) \)
\( h\nu_{\text{HgCd*}} = 2.6 \text{ eV} \ (470 \text{ nm}) \)
\( A = \text{geometric cross section of discharge} \ (1.25 \text{ cm}^2) \)
\( \ell = \text{discharge path length} \ (40 \text{ cm}) \)
\( i = \text{discharge current} \ (50-100 \text{ A}) \)
\( V = \text{discharge voltage} \ (10-15 \text{ kV}) \)
\( \tau = \text{discharge pulse duration} \ (\sim 1.5 \mu\text{sec}) \)

The determination of [HgCd*] was reported on in the last quarterly report. Operating under the above conditions, we typically measure [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

\[
e_p + \text{Ne} \rightarrow \text{Ne}^+ + e_p + e_s \tag{2}
\]
\[
e_s + \text{Cd} \rightarrow \text{Cd*} + e_s \tag{3}
\]
\[
\text{Cd*} + \text{Hg} + \text{M} \rightarrow \text{HgCd*} + \text{M} \tag{4}
\]
Thus, the quantum efficiency for producing an HgCd* goes as the ratio

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

(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 ~1.5 µsec pulse is preionized by an ~200 A Febetron pulse occurring ~100 nsec before the discharge. The discharge voltage is ~13 kV and the discharge current rises during the pulse from ~50 A to ~100 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 ~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 ~2 µsec 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
Figure 1  Schematic of Gain/Absorption Measurement
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 [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
REFERENCES


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