KINETIC PROCESSES IN NON-HEATED COPPER VAPOUR LASER

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Copper vapour lasers attracted attention owing to their high efficiency in the visible region of the spectrum. In conventional copper vapour lasers, a temperature of 1500°C is needed to achieve the required vapour pressure. A lower temperature (400°C -600°C) is required in a double-pulse lasers using copper halides (1,2). These temperatures are usually obtained by power dissipation of the applied discharge operated at a relatively high repetition rate (3). A promising method for decreasing the working temperature of a copper vapour laser is the pulsed introduction of vapour into the working volume of the laser (4,5,6).

Copper vapour laser with inductively produced copper plasma, which is accelerated by a pulsed magnetic field, operates at room temperature in a double-pulse mode (7). The magnetic field was generated by the discharge of a capacitor (0.7 µF, 30KV) through a solenoid mounted outside a glass tube (10cm bore and 175cm long) filled with helium.

The population densities of both the ground and $^2D_{5/2}$ metastable states of copper atoms were derived from measurements of the optical absorption at 324.7nm and 510.6nm, respectively, over a wide range of the helium pressure. These measurements were made along the tube axis and across the tube to eliminate the influence of the heterogeneities of the copper vapour moving in the axis direction at the instant of vapour production.

A triggered xenon flash tube was used as the source for absorption measurements.

A lens focused the light onto the enterance slit of a 1-m monochromator equipped with 10µm slits and a photomultiplier tube (PMT) at the exit slit.

The PMT signal was displayed on an oscilloscope and recorded on Polaroid film.

Ground state and metastable copper densities were computed from the measured absorption by employing the methods described by Mitchell and Zemansky (8). The absorption coefficient of the copper ground state or metastable state was obtained using the Voigt profile, which includes the effects of Doppler, natural resonance, and Van der Waals broadening. The hyper-fine structure and isotope shift were taken into account in the calculation.

The temporal variation of the temperature in the afterglow was studied by fast-scaning Fabry-Perot spectroscopy (9). The temperature of the copper vapour was determined from the Doppler broadening of the 521.8nm copper line. This line was selected in order to exclude isotope shift effects.

The temperature measurements were made across of the tube to exclude the velocity broadening effects of the moving copper vapour along the axis direction.

The temporal variation of the temperature of the copper vapour (Fig.1) was taken into account for line profile interpretation.

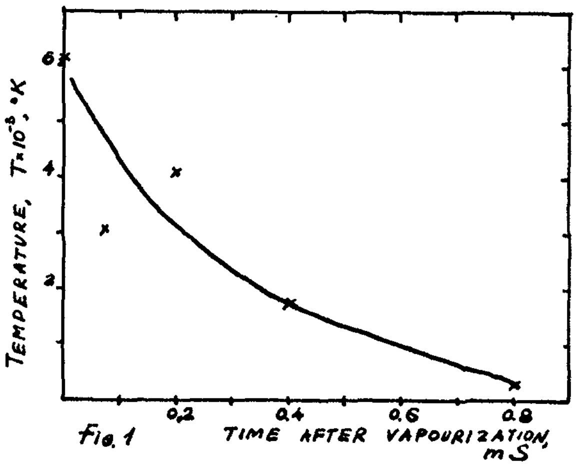

Fig. 1

The slit function was determined with the help of a copper hollow-cathode lamp. The slit function was used to calculate absorption coefficients from a continuum radiation source.

The densities of both the ground and metastable states of copper atoms with helium at different pressures are shown in Fig. 2.

Only measurements of the ground-state densities at higher helium pressures are shown as metastable levels were not detectable.

The metastable level density decays rapidly from an initially high value while the ground-state densities exist up to 2ms. without noticable changes.

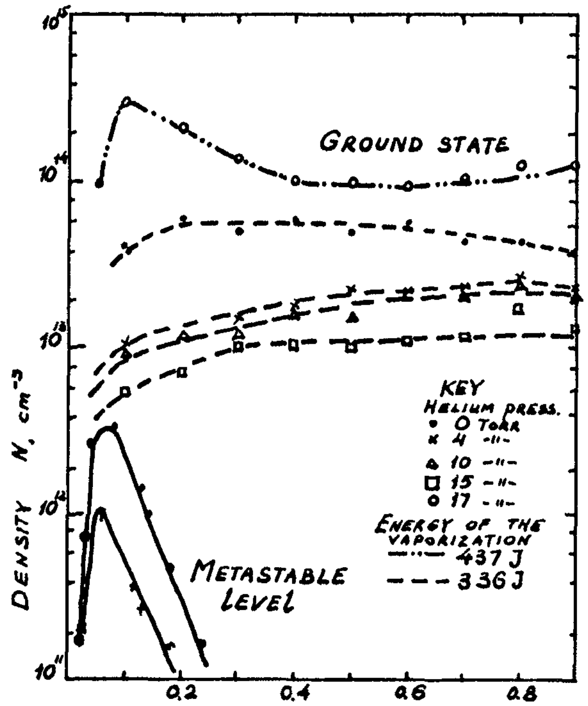

Fig2. TIME AFTER VAPOVRIZATION PULSE, mS

In our experiments a longitudinal excitation pulse from a 3500pF capacitor charges to 30KV was applied 300-2000 μsec after the vapour production. Lasing was obtained only with low helium pressure (2 torr), because of the difficulty of obtaining a longitudinal glow discharge between electrodes separated by 175 cm.

The maximum laser output energy was 10mJ with a pulse duration of 150nsec. Lasing on both green and yellow lines was detected. The mentioned laser energy was obtained without optimization of laser parameters.

Study of high efficiency copper lasers with pulsed production of vapour is carried out by the authors.

REFERENCES

1. C.I. Chen, N. Nerheim, and G. Russel Appl. Phys. Lett. 23, 514 (1973)
2. I. Liberman, R. Babcock, C. Lin, T. George and I. Weaver, Appl. Phys. Lett. 25,334 (1974)
3. A. Isarv, M. Kazaryan and G. Petrash, ZhETF Pis. Red 16,40, (1972)
4. G.R. Russel, N.M. Nerheim and T.J.Pivitotto, Appl. Phys. Lett. 21, 565 (1972)
5. J.F. Asmus ans N.K. Moncur, Appl. Phys. Lett. 13,384 (1968)
6. A.M. Shukhtin, G.A. Fedotov and V.G. Mishakov, Opt. Spectroscopy 40, 237, (1976)
7. A. Ludmirsky. Laser (file patent applic. in the USA, N889396 from 28/3/78).
8. A.C. Mitchell and M.N. Zemanski, Resonance Radiation and Excited Atoms (Cambridge University Press, London , 1961)
9. A. Ludmirsky, C. Cohen and Yu. M. Kagan Appl. Optics, Jan 1979.