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Output of Laser Beam is Strongly Dependent on Electron Temperature in the Discharge Tube

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Abstract: ***We have investigation the radial profile at different time during the formation of the laser pulse. It is found that the radial profile of spectral emission is not same at all the times during the formation of the laser pulse. The radial profile go on changing the shape as a function of time. In some case the electron temperature is relatively low, the radial profile are almost Gaussian at all the times, however the peak height goes on changing. For the explanation of the radial and temporal profiles concept of fractional abundance is very much essential. It can be noted that the intensity of the output laser beam is strongly dependent on electron temperature in the discharge tube. The temporal distribution of the laser output at 20,21and 22 KV are identical to those obtained for 2,4and 10eV the initial electron temperature at the axis respectively.***

Keywords: Copper Vapour Laser, inversion density, dimensions, laser radiation, of the laser plasma.

1. Introduction

The CVL (Copper Vapour Laser) is well recognized source of light delivering pulsed laser beam at 5106 and 5782A at the pulse repetition frequency of 5 kHz with power levels up to about 100 watts or more[1-2]. The design calculations of the high power and high precision lasers need the detail information about the parameters like electron temperature, electron density, ion density, fractional abundances, electron impact excitation etc. The spatial and temporal profiles of these parameters, also must be known in order to design efficient and sophisticated laser systems. In case of temporal and radial profiles the fundamental parameters like discharge current, the discharge voltage, the electron temperature, electron density, ion density varies from zero through their maximum values[3]. In design of amplifier oscillator configuration system the detailed knowledge of the spatial distribution of the densities is very much important because different parts in the discharge tube have different densities and inversion times. Therefore, the study of the spatial and temporal profiles of the parameters is very much essential.

We calculate fractional abundances of CuI (copper atoms), Cull (singly ionized copper atoms), CuIII (doubly ionized copper atoms) and CuIV (triply ionized copper atoms) as a function of electron temperature. The electron impact excitation rate coefficients are also obtained as a function of electron temperature from zero through 10ev. The radial profiles of the spectral emission of the discharge are also obtained. The temporal and spatial distribution of the laser output power are studied in details. When the discharge pulse is fired the electron temperature is maximum as the electric field is maximum. Afterwards time passes the electron temperature go on decreasing. The temporal profiles of electron temperature is assumed to be exponentially decreasing and power distribution along and across the laser beam are obtained.

2. Radial Profiles of Electron Temperature and Electron Density

The variation of electron temperature and electron density across the discharge tube gives rise to radial variation of the fractional densities and energy level densities and it results in the radial profiles having different shapes.The electrons near the walls must be at very low temperature and the electrons at the tube axis must be hottest as they are least affected by the collisions with the walls. Therefore, the electron temperature profile which we have to consider should give maximum electron temperature at the axis and minimum electron temperature near the walls. We assume the electron temperature profile to be given by the equation.

$$T(R) = To\ [1 - (R/R_o)] \qquad \text{------ (1)}$$

where T(R) is the electron temperature at a distance R from the axis , To is the electron temperature at the axis and Ro is the radius.

3. Variation of Output Power along and Across The Laser Beam

When the discharge pulse is fired the plasma electrons get heated suddenly to a high value within about 5-10 nsec because of the process of acceleration of electrons by the electric field generated by pump pulse of the discharge tube. As time passes the plasma electrons undergo collisions with other particles and discharge tube wall and consequently start getting cooled. In most of the CVL systems the heating time is shorter than the cooling time τ. [4]The temporal behavior of the electron temperature is assumed to be given by the expression

$$T_0 = T_{inio} \exp(-t/\tau) \qquad \text{--------- (2)}$$

Where T_{inio} is the initial electron temperature at the axis i.e. the electron temperature when the discharge pulse is fired and the plasma gets heated to maximum temperature. T_0 is the temperature at the axis of the discharge tube at the time t. The temperature T_0 at the axis at any time t may be obtained using equation (2).

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4. Results and Discussion

We compute the temporal profiles of the spectral emission of the discharge for the initial electron temperature T_{into} = 2, 8, and 10 eV and the results are displayed in the figures. 1,2, and 3 respectively. For the low initial electron temperature (2eV) the radial profile of the spectral emission is almost Gaussian in shape and remains Gaussian during the complete output pulse. Initially the peak intensity is low, then it increase reaches its maximum value and then go on decreasing.

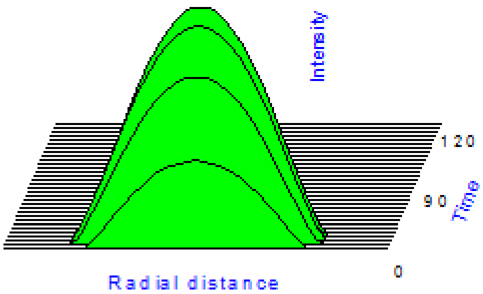

Fig 1: Temporal and spatial distribution of laser output power for initial electron temperature T_{in}=2eV

In the lagging portion of the pulse the radial profiles are flat. The dip at the axis is exhibited for about 25 nsec after the pulse starts building up. At later times the radial profile go on changing the shape and the dip in the profile go on becoming shallower. The dip go on decreasing from leading part to the lagging part. For the initial electron temperature of 8eV the beam remains annular for longer time duration and the radial profiles exhibit dip at the axis and the dip go on becoming shallower in the lagging part of the beam

For initial electron temperature of 10 eV the beam becomes completely annular. We investigate the diameter of the annular beam by changing the electron temperature in the neighborhood of 10eV. It is found that the diameter of the ring of the radiation is determined by the initial electron temperature at the axis. If the electron temperature is increased the diameter of the ring increases.

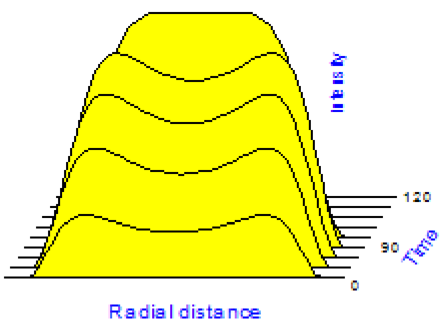

Fig 2: Temporal and spatial distribution of laser output power for an initial electron temperature T_{in}=4eV

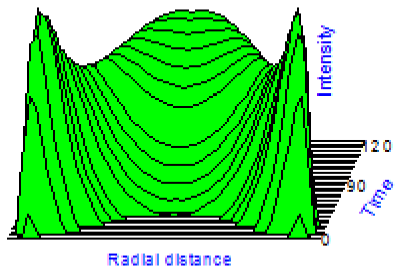

Fig 3: Temporal and spatial distribution of laser output power for an initial electron temperature T_{in}=10eV

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