Optics Communications 284 (2011) 1318–1321

Contents lists available at ScienceDirect

Optics Communications

journal homepage: www.elsevier.com/locate/optcom

The effect of an axial external magnetic field on the output power of a small-bore CuBr laser

F. Rahimi Ashtari [a], S. Behrouzinia [b], B. Sajad [a,*], M. Zand [b]

[a] Physics Department, Alzahra University, Tehran, Iran
[b] Laser and Optics Research School, Nuclear Science and Technology Research School, Atomic Energy Organization of Iran, Tehran, Iran

ARTICLE INFO

Article history:
Received 30 June 2010
Received in revised form 20 September 2010
Accepted 26 October 2010

Keywords:
CuBr laser
External magnetic field
Small-bore tube

ABSTRACT

In this work, the effect of an axial external moveable magnetic field on the output power of a CuBr laser with small-bore tube has been investigated. In all experiments, by applying an EMF along the tube axis, the laser output power has been decreased and by moving the EMF toward the cathode region, more substantial decrease of output power has been observed. The effect is more significant at a magnetic field intensity of 1100 G, Ne gas pressure of 35 Torr, frequency of 19 kHz and voltage of 3.8 kV, such that there was no laser emission when the EMF was placed around the cathode.

1. Introduction

Considerable attention has been given to lasers utilizing the vapors of different compounds of copper. The application for the copper laser at two principal visible outputs of 510.6 and 578.2-nm, includes high-repetition rate pumping of tunable dye lasers, high-speed flash photography, large image projection television and material processing. A technique for using copper halide as the source of copper atoms in a copper vapor laser (CVL) was first reported in 1973. The operating temperature of copper halide lasers (400–600 °C) depends on the vapor pressure and type of the compounds and is much lower than that of the pure CVL (1550–1700 °C). This advantage yields a significantly shorter warm-up time for the halide laser, which is important to reduce downtime in commercial applications [1–7]. Numerous experimental investigations have been performed to increase the efficiency and average output power of CVL [8–10]. One of the intended methods to obtain high power is employing a large-bore tube. However, in this case the high-density free electrons remain between the pulses due to a high-temperature plasma near the tube axis [11]. These high-temperature electrons excite the low-energy-level copper atoms (meta-stable state) and also increase the radial plasma conductivity which results in the decrease of intensity of the laser output pulse originating from the tube axis. This pulse is also delayed with respect to the pulse originating from the active region near the tube wall. High-gas-pressure and low-pulse repetition-frequency operations as well as the using of axial cooling plates were previously considered to improve the laser output profile [11–15]. Moreover, the application of an external magnetic field (EMF) on a large-bore copper-hybrid laser was performed experimentally to increase the overall output power of the large-bore CVL [16]. Applying a sufficiently strong axial EMF causes an important effect on the CVL's active medium. The EMF forces the ionized gas to move spirally under Lorentz force and also reduces the radial plasma conductivity. Similar work on a small-bore CuBr laser in the presence of an EMF has shown the increase of the output power, too. However, this effect is reduced by increasing the buffer gas pressure. Besides, it was numerically shown that the increase of output power of a large-bore tube is much more than that of a small-bore tube at EMF [17]. Further experiments were performed to study the effect of Z dependence EMF on the output power of a small-bore CuBr laser. It was shown that the output power increases if the solenoid covers only the cathode of the laser tube. By moving the EMF along the tube axis from the cathode toward the anode, the increase of output power is reduced such that it has a negative effect on the output power when the solenoid covers the anode of the tube [18].

In this work, the effect of an axial external magnetic field on the output power of a CuBr laser with small-bore tube was investigated. It is shown that there is reversal in the output power behavior of a small-bore CuBr laser at the presence of EMF. The intensity and position of the EMF have been individually changed along the tube axis to investigate the effect of a moveable EMF on the laser performance. No increase of the laser output power has been observed, neither when the solenoid covers the cathode nor the anode. In all experiments, by applying an EMF along the tube axis, the laser output power has been decreased and by moving the EMF toward the cathode region, more substantial decrease of output power has been resulted.

* Corresponding author. Tel.: +98 9123113562; fax: +98 2188049936.
E-mail addresses: sajjad79@yahoo.com, bsajad@alzahra.ac.ir (B. Sajad).

0030-4018/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.optcom.2010.10.090

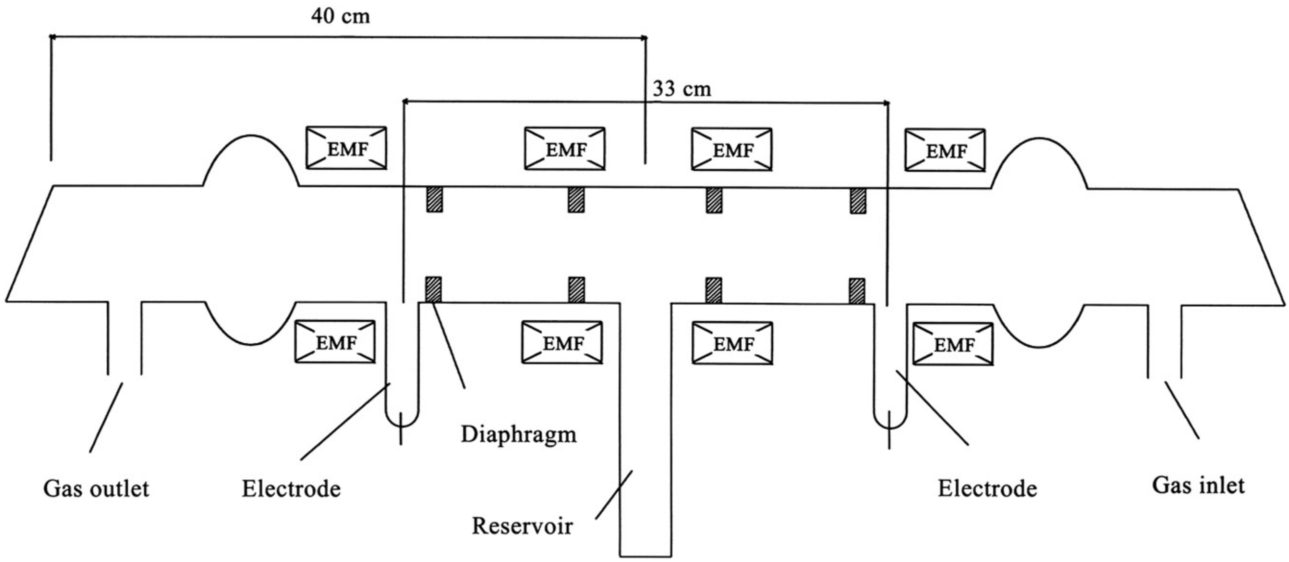

Fig. 1. Schematic diagram of the laser tube.

2. Experimental setup

The laser schematic diagram of discharge tube is shown in Fig. 1. The discharge is contained within a quartz tube of 20-mm bore between electrodes which are separated by 33 cm. The total length of the laser tube, including the extended windows regions, is 80 cm. Four diaphragms are employed in order to confine and stabilize the discharge. One heated side-arm reservoir of high purity CuBr powder, which is located at the middle of the tube, is used to seed the discharge zone with CuBr vapor. The temperature of the reservoir is typically 420 °C, while the discharge channel is held at a slightly elevated temperature, so that the side reservoir temperature controls the vapor pressure of CuBr in the main tube.

Each electrode is a quartz side-arm with a tungsten quartz feed-through in its base and is filled with copper filings, to which the discharge is attached. Two cool traps are also introduced between the electrodes and each end, which are closed by an end cap with a window and a pair of gas ports for the flow of the buffer gas. The laser cavity is formed by a flat dielectric coated high reflector at both laser wavelengths, and an uncoated quartz flat acts as an output coupler.

The laser tube is coupled to the standard driven circuit as shown in Fig. 2. The gas on the tube is excited by the discharge of a 0.68-nF main capacitor (C_s) through the TGI1-1000/25 thyratron, which is cooled with air. A 0.47-nF peaking capacitor (C_p) is connected between the tube electrodes as well as the 0.18 mH inductance (L_2).

A solenoid with 5 cm long and 11 cm inner diameter is used to provide the magnetic field with the maximum intensity of 1100 G on the axis of the solenoid. The laser tube is placed inside the solenoid such that the solenoid can be easily moved along the tube axis.

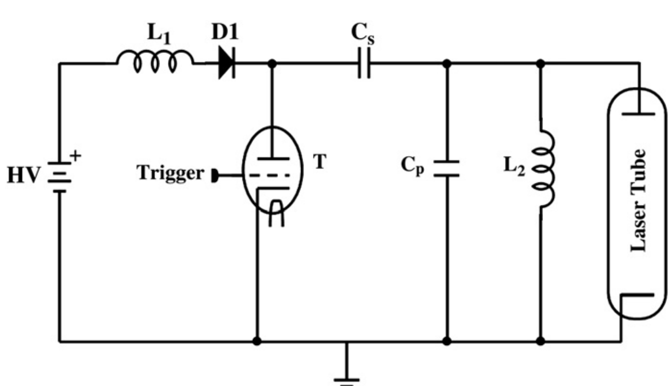

Fig. 2. The standard driven electrical circuit for CuBr laser.

The experimental characteristics of the laser output are measured by a Tektronix™ oscilloscope; model TDS-1250, a Molectron™ PM500D power meter, and a semiconductor detector model pbx-65. The light emission of the laser is detected by a spectrometer model S150 Solar Laser Systems™ (200–1100 nm) accompanied by CCD array detector.

3. Results and discussion

At first, the output power of CuBr-Ne laser was measured versus various parameters such as buffer gas pressure, electrical input power and repetition frequency to obtain the optimal condition of output power. It was determined to be 3 W at 35 Torr neon buffer gas pressure, 4.2 kV input voltage and 20 kHz repetition rate.

The experiments at the presence of external magnetic field have been carried out under the optimal conditions to investigate the effect of EMF on the output power by changing the position of the solenoid along the tube and the intensity of the EMF. In all cases, it was unexpectedly seen that the EMF apparently decreases the output power, at both laser transitions. Fig. 3 depicts a typical laser output spectrum without and with applying 600 G EMF where the solenoid was placed around the cathode.

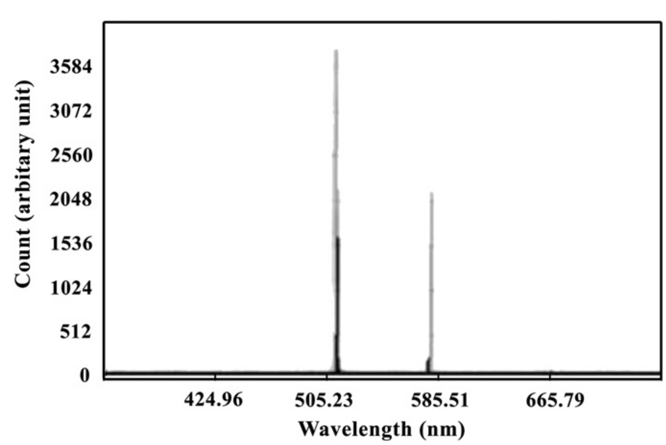

Fig. 3. The spectrum of laser output without EMF (grey line) and with 600 G EMF (black line) around the cathode.