ELECTRON BEAM PUMPED CW Se II LASER ☆

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We have observed cw laser action in 15 transitions of singly ionized selenium using an electron beam to excite a He-Se mixture. The variation of the laser output power as a function of the electron beam discharge parameters is reported.

Recently we obtained cw laser radiation from singly ionized Hg and I using electron beam pumping of He-metal vapor mixtures, and we suggested that this new excitation could be extended to a large number of ion lasers [1,2]. Here we report the observation of cw laser action in 15 transitions of singly ionized selenium using a d.c. electron beam to excite a He-Se mixture.

The He-Se ion laser is one of the most prominent laser systems for multi-wavelength cw oscillation. Cw laser oscillation in Se II was first obtained by Silvfast and Klein [3], using the positive column region of a He-Se discharge as the laser active medium.

Laser action in Se II was also obtained in a hollow cathode [4]. Hollow cathode discharges have a small electron beam component that produces large densities of ground state helium ions despite relatively large proportions of low ionization metal vapor into the discharge. As a consequence, many metal vapor ion laser transitions pumped by charge transfer are known to have enhanced performance in hollow cathode discharge configurations compared to their performance in a positive column. However, the He-Se hollow cathode laser has proven to be difficult to operate due to discharge instabilities attributed to chemical action between selenium and the metal components of the cathode tube [4].

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In the electron beam arrangement we used to obtain cw laser action in Se II, the electron beam generation region and the laser active medium are separated from each other. Consequently, the electron beam generation is not affected by the selenium concentration in the laser active medium.

The experimental set up employed is the same one we used to obtain cw laser radiation in Hg II by electron beam excitation [2]. The d.c. electron beam, of energy between 1 and 5 keV and a current up to 1 A, is generated by a glow discharge electron gun that operates in He at pressures between 0.1 and 3 torr without needing differential pumping.

The electron gun has a path throughout the optical axis [5] that permits us to match the electron beam created plasma volume with the corresponding volume of the optical resonator. The laser active medium is an electron beam created plasma, magnetically confined, contained in a plasma tube 1.1 cm in diameter and 120 cm long. An axial magnetic field helps to efficiently deposit the electron beam energy into the plasma. The electron beam generation region and the plasma tube are separated by a water cooled selenium trap. The selenium vapor is introduced into the discharge from an independently heated sidearm attached to the other end of the plasma tube. We flow He through the system at 200 to 400 standard cm^3 per minute to aid the distribution of selenium vapor throughout the discharge region and to continuously purge the system of gaseous impurities.

Using broad band dielectric mirrors of 2 m radius

Table 1
Wavelengths and level assignment

Wavelength	Level Assignment
4975.7	$5p\ {}^2D^o_{5/2}-4s\,4p^4\ {}^2P_{3/2}$
4992.7	$5p\ {}^4P^o_{3/2}-5s\ {}^4P_{3/2}$
5068.6	$5p\ {}^4P^o_{5/2}-5s\ {}^4P_{5/2}$
5142.1	$5p\ {}^4D^o_{3/2}-5s\ {}^4P_{1/2}$
5176.0	$5p\ {}^4D^o_{5/2}-5s\ {}^4P_{3/2}$
5227.5	$5p\ {}^4D^o_{7/2}-5s\ {}^4P_{5/2}$
5253.1	$5p\ {}^2D^o_{5/2}-5s\ {}^2P_{3/2}$
5253.6	$5p\ {}^4D^o_{1/2}-5s\ {}^4P_{1/2}$
5305.3	$5p\ {}^2D^o_{3/2}-5s\ {}^2P_{1/2}$
5522.4	$5p\ {}^4P^o_{3/2}-5s\ {}^4P_{5/2}$
	or $5p\ {}^4P^o_{5/2}-4s4p^4\ {}^2P_{3/2}$
5591.2	$5p\ {}^4P^o_{3/2}-5s\ {}^2P_{1/2}$
6056.0	$5p\ {}^2P^o_{3/2}-7$
6444.2	$5p\ {}^2D^o_{5/2}-7$
6490.5	$5p\ {}^4D^o_{1/2}-5s\ {}^2P_{1/2}$
7838.8	$5p\ {}^4P^o_{1/2}-4s4p^4\ {}^2P_{3/2}$

of curvature we obtained cw laser action in the 15 transitions of Se II listed in table 1. All transitions originate from the $4s^2\ 4p^2\ 5p$ excited electronic configuration in Si II, which is energetically close to the He ion ground state. Charge transfer between He ions in the ground state and Se atoms is proposed to be the dominant excitation mechanism.

The 5305.3 Å transition presented the lowest observed current threshold of 350 mA, corresponding

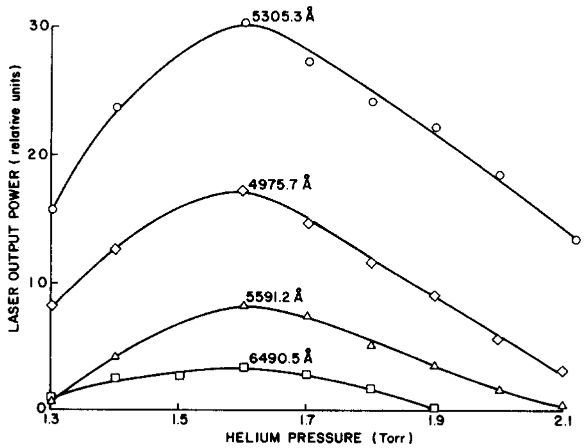

Fig. 1. Laser output power as a function of average helium pressure in the plasma tube, at a current of 800 mA, a sidearm temperature of 310°C and a magnetic field of 3.7 kG.

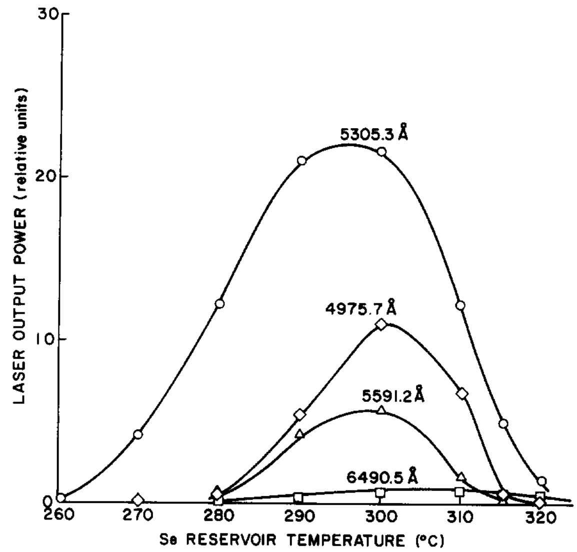

Fig. 2. Laser output power as a function of selenium sidearm temperature. Current 800 mA, magnetic field 3.7 kG, average helium pressure 1.6 torr.

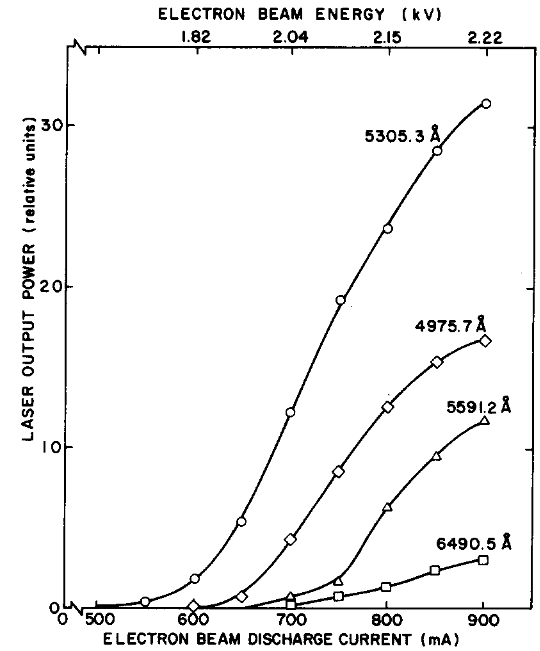

Fig. 3. Laser output power as a function of magnetic field. Current 800 mA, sidearm temperature 300° C, average helium pressure 1.6 torr.

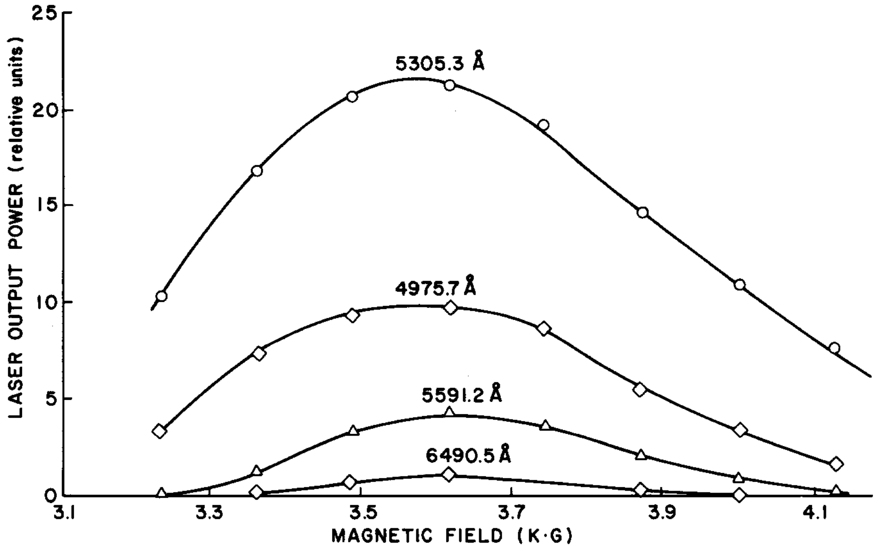

Fig. 4. Laser output power as a function of electron beam discharge current and voltage. Sidearm temperature 300°C, magnetic field 3.6 kG, average helium pressure 1.6 torr.

on electron beam discharge voltage of 1.6 kV. Under most discharge conditions this was also the strongest laser transition.

The variation of the laser output power with discharge parameters was measured simultaneously for the different lines using an optical multichannel analyzer. The dependence of the strongest laser lines: 5305.3 Å (green), 4975.7 Å (blue), 5591.2 Å (yellow), and 6490.5 Å (red) as a function of the average helium pressure in the plasma tube is shown in fig. 1. Figs. 2 and 3 show the laser output dependence of the lines as a function of selenium sidearm temperature and axial magnetic field respectively, at a current of 800 mA and an average He pressure in the plasma tube of 1.6 torr. The variation of the laser output power as a function of the electron beam discharge current and voltage, corresponding to the optimum helium pressure, selenium density and magnetic field is shown in fig. 4.

A laser output power of 20 mW was measured for the 5305.3 Å and 4975.7 Å transitions combined using an output mirror with 1.5% and 2.5% transmittance at 5300 Å and 4970 Å, respectively. The output coupling mirror was not optimized.

In summary, we have obtained for the first time, cw laser action in singly ionized selenium using d.c. electron beam excitation. Cw laser radiation was obtained in 15 transitions of Se II in a He-Se mixture.

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