Paper

Radio frequency excited CW gas ion lasers

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ABSTRACT

We report the designs and performances of He-Cd^+, He-Kr^+, He-Ar^+, He-Se^+, He-Cu^+(CuBr) and Ne-Cu^+(CuBr) lasers excited with the transverse capacitively coupled radio-frequency discharge. At the similar laser output parameters the designs and operation of the radio-frequency excited lasers are much simpler than those of the hollow-cathode discharge lasers. Under single-line operation the radio-frequency excited He-Cd^+ laser delivered output powers of 60 mW at 441.6 nm, 36 mW at both 533.7 nm and 537.8 nm, and 14 mW at both 635.5 nm and 636.0 nm. The output powers of the He-Kr^+ laser were 22 mW at 469.4 nm, and 11 mW at 431.8 nm. Both lasers exhibited the rms noise-to-signal ratio (0.4-0.6 %) much lower than that of conventional positive column He-Cd^+ lasers. Using a He-CuBr gas mixture laser action on four infrared CuII lines (740.4 nm, 766.5 nm, 780.8 nm and 782.0 nm) was achieved and with a Ne-CuBr gas mixture laser gains on 14 UV-lines between 240.3 nm and 272.2 nm were observed.

INTRODUCTION

Recently the technology of several gas ion lasers has been essentially improved in our laboratories by employing the transverse capacitively coupled radio-frequency (CCRF) discharge for the laser excitation. This concerns such lasers as He-Cd^+, He-Kr^+, He-Ar^+, and He-Cu^+(CuBr) lasers, successful operation of which was previously proved using the hollow-cathode discharge (HCD). As it was shown by us, operation of the gas ion lasers excited by the transverse CCRF discharge can be realized with the technology much simpler than that of the HCD lasers, at the similar laser output parameters. This make the transverse CCRF discharge attractive for excitation of the gas ion lasers.

Historically, the laser excitation capability of the transverse CCRF discharge has resulted in a considerable number of visible and infrared ionic transitions in Tl, Cd, Zn, Hg, Se, Cu, Kr, and Ar (1-3). However, technological problems encountered in the CCRF discharges, such as overheating of the discharge tube, deterioration of the inner wall surface of the laser tube by the ion bombardment and introducing of the wall-originated particles into the discharge, have limited the previously carried out investigations mainly to a quasi-CW or pulsed operation regime of the CCRF-excited lasers.

In this contribution results of our effort to develop simple CCRF-excited lasers, exhibiting long-life and stable generation in CW regime are presented.

DESIGNS AND PERFORMANCES OF CCRF-EXCITED He-Cd^+, He-Kr^+, He-Ar^+, He-Se^+, He-Cu^+, AND Ne-Cu^+ LASERS

He-Cd^+ LASER

For practical realization of a long-life CW CCRF-excited He-Cd^+ laser we developed a laser tube, the design of which is shown in Fig. 1. A capillary tube made of Al_2O_3 ceramic (the length - 400 mm, the inner diameter - 4 mm) was inserted into the centrally placed fused silica capillary tube, forming the active part of the laser tube. Using the Al_2O_3 capillary tube allowed to lower the sputter-originated problems, whereby a stable continuous operation of the laser was achieved.

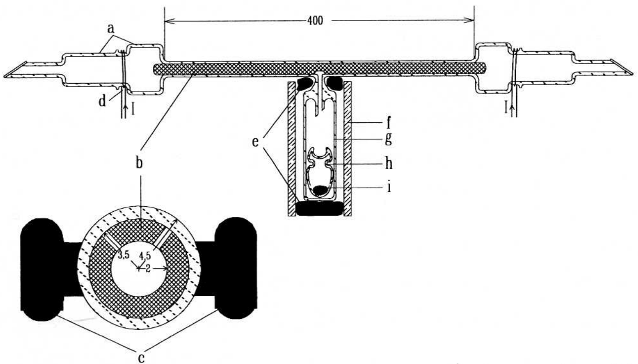

Fig. 1. Design of the CCRF-excited He-Cd^+ laser tube with Al_2O_3 capillary tube insert: a-fused silica tube, b- Al_2O_3 capillary tube, c-RF electrodes, d-heaters, e-insulating material, f-oven , g-Cd reservoir, h-ampoule, i-cadmium.

The RF power was capacitively coupled into the discharge with transverse nickel-plated copper electrodes mounted along the fused silica capillary tube. The discharge was run by a RF generator operating at 13.56 MHz with an output power up to 600 W. A special matching circuit (Fig. 2) was used to transform the laser discharge tube impedance to the 50 Ω output resistance of the RF generator. The matching circuit, consisting of two capacitors and a transformer, symmetrized the RF voltage and was essential to maintain a uniform discharge between the electrodes and to avoid strong RF interference. Both, a nonuniform discharge spreading outside the electrode gap and strong RF interference occurred when a nonsymmetric matching was used. The symmetrizing transformer consisted of two coils, the primary of inductance $L_1 = 2.74$ μH, and the secondary of inductance $L_2 = 11.43$ μH. The capacitances could be varied from 45 pF to 650