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Laser capabilities of CuBr mixture excited by RF discharge

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Abstract. Our investigations demonstrated that utilizing copper bromide (CuBr) mixture as a source of Cu atoms in a RF-excited discharge can be a promising alternative to the Cu sputtered system, when the development of Cu ion gas laser is considered. Both spectroscopic and laser investigations showed that the threshold input power for lasing was reduced about 5 times using the CuBr-based system instead of the Cu-sputtered system. Pulsed and CW laser oscillation on Cu^+ transitions in the near IR spectral region was obtained in RF-excited He–CuBr discharge operated at 13.56 MHz and 27.12 MHz. At input RF power of 800 W, a laser output power of 10 mW at the 780.8 nm Cu ion laser line was achieved. An increase of laser output power by a factor of two, as well as better Cu vapour axial distribution and better discharge stability, was attained when DC discharge was superimposed on the RF discharge. Laser gain on 11 UV Cu ion lines was observed in RF-excited Ne–CuBr discharge. basing on the obtained results, we consider the CuBr laser system excited by RF discharge capable of generating UV laser radiation at relatively low input power.

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1 Introduction

The copper ion (Cu^+) laser is one of the most efficient metal ion lasers, capable of generating CW laser lines in a wide spectral range extending from the near IR to the deep UV (54 laser lines in total, 11 of them in the UV, [1]). Two methods have been employed for producing the laser medium with Cu^+ ions excited to the upper laser levels. In the first method, discharge sputtering of the copper electrode is used to produce free Cu atoms, which then are ionised and excited to the upper laser levels. The Cu^+ lasers excited with this method are called the *sputtered copper ion lasers*. However, in the sputtered Cu^+ lasers a rather high input power (more than 100 W/cm, [2,3]) is necessary to obtain the required Cu atoms density in the laser medium. An alternative method for producing free Cu atoms in the laser medium is to seed the discharge with a copper halide (*e.g.* copper bromide), similarly to the pulsed selfterminating metal vapour lasers [4–6]. The Cu^+ lasers employing copper halides as a source of Cu atoms are called the *halide-based copper ion lasers*.

In the sputtered Cu^+ lasers a *hollow cathode (HC) and a radio frequency (RF) discharge* have been used for sputtering the copper electrode to obtain free Cu atoms in the laser medium.

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Laser output power of about 1 W at CW operation and about 5 W at quasi CW operation (pulse duration of 100 μs, repetition rate of 40 Hz) have been reached at 780 nm in the sputtered Cu^+ lasers excited by HC discharge [7]. The record value of the laser output power in the UV region around 260 nm is about 900 mW under multiline operation [8]. This makes the Cu^+ lasers very attractive for various applications in biology, medicine, microelectronics, etc. However, to make the HC discharge-excited Cu^+ laser a practical device a lot of problems exist connected with the poor stability of the HC discharge, short life-time, complicated and expensive design of the discharge tube, etc.

It has been demonstrated that many ionic laser lines, which can be generated in a HC discharge, can be also efficiently excited in a RF discharge, in particular in a capacitively coupled RF discharge (see, *e.g.* [9]). The capacitively coupled RF discharge excitation [9–12] offers high longitudinal homogeneity of the discharge, more efficient transforming of the input power into energy of the fast electrons, better stability of the discharge, less complicated laser tube design and possibility of using external electrodes. These advantages have been recently demonstrated by the efficient CW operation of RF-excited He–Cd^+ and He–Kr^+ lasers [11,12].