CAPABILITIES OF A METAL VAPOR LASER PUMPING SYSTEM WITH A FORMING CIRCUIT

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The use of a pumping system with an additional forming circuit has allowed us to improve the output characteristics of copper and gold vapor lasers and to prolong the service lives of a commutator due to better load matching and a sealed-off active element due to the increase of the buffer gas pressure.

The present paper describes a rather simple system for pumping of a metal vapor laser (MVL). This system ensures reliable operation of the standard TGI1-1000/25 commutator and effective excitation of an active medium at the repetition rates up to 20 kHz.

It is well known that optimal mean power and efficiency of MVL lasing with the working channel diameter ≤ 1 cm are realized at pumping pulse repetition rates more than 10 kHz (this is the case at least for copper and gold vapor lasers[1–3]). In this case, a pump power density per pulse must be reduced to decrease the working capacitance. This leads to unstable operation of the excitation circuit because of a finite self-capacitance of the commutator-thyratron.

One way to "unload" the thyratron and to obtain effective pumping is to use forming circuits with nonlinear elements in the excitation circuits.[4] One of such circuits, shown in Fig. 1, was tested. Here, L_1 is the air inductance (~ 180 mH), L_2 (5 mH) is a solenoid wound round a former 2 cm in diameter. The inductors L_3 and $L_{3'}$ are the MGSV wire wound round the mark 600 NN ferrite rings. The mark KVI-3 accumulating capacitor C_1 (1 nF) and recharge capacitors C_2, C_3, and C_4 are used. In the figure, VL_1 denotes the thyratron and VD denotes the KD-213 diode pack.

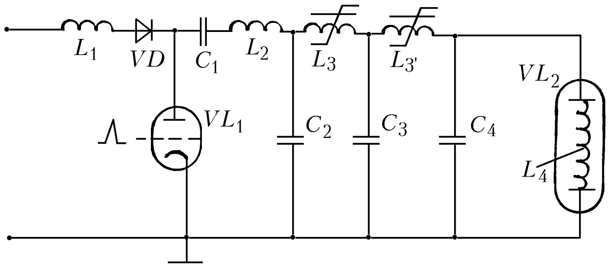

FIG. 1. Excitation circuit with nonlinear elements.

The given circuit has some advantages over the circuit of direct discharge of the capacitor through the thyratron and active element. So, for the active element with a diameter of 1 cm and a length of 50 cm a mean output power of 2.5 W was obtained for the copper vapor laser at an excitation pulse repetition rate of 3 kHz. In the experiments, a discharge tube VL_2 with an additional heater was used.[5] When the additional heater was turned off, the active element operated as a typical self-heating one. The coil of wire played the part of an inductor (L_4) shunting the discharge. In this case, a power of 800 W was removed from the supply line 220 V/50 Hz. At the same time, the increase of the frequency up to 10 kHz led to heating up of the nonlinear inductors L_3 and $L_{3'}$ and increased losses. The use of the additional heater, as we have already noted,[6] though shortens the time of laser putting into the stable regime of lasing, slightly reduced the laser output parameters.

To increase the pumping pulse repetition rate, a system with linear electric circuits (Fig. 2) was checked. In the system the active element with peaking capacitors C_2 and C_3 (0.2 nF) possesses the properties of a parallel oscillatory circuit that leads to a delayed increase of the current passing through the active element (relative to a voltage pulse, Fig. 3). After completion of the main excitation pulse, the power accumulated in the inductor L_4 passes back to the discharge gap during 200–300 ns. The highest output power of the copper vapor laser was obtained in the helium-neon mixture in a ratio 1:4 at a total pressure of 150 Torr. At a pumping pulse repetition rate of 12 kHz the net mean power at both lasing lines (510.6 and 578.2 nm) was 6 W with efficiency of 0.8%. The laser pulse duration slightly exceeded that for the pumping circuit with direct discharge of the capacitor. For the gold vapor laser with the same active volume the mean power of lasing at 627.8 nm was 1.6 W with efficiency of 0.3%. The typical (nonforced) laser output powers in the case of "direct circuit" were 2 W for the copper vapor laser and 0.5 W for the gold vapor laser.

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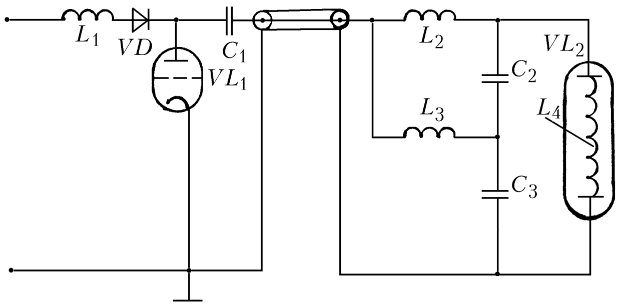

FIG. 2. Pumping system with linear electric circuits.

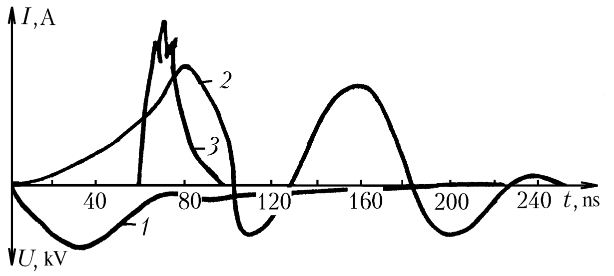

FIG. 3. Oscillograms of the pulses of voltage (1), current (2), and power of lasing (3) (net power at both lasing lines of the copper vapor laser).

Thus, the use of the proposed circuit allows one on the one hand, to improve the output characteristics of small-sized metal vapor lasers and on the other hand, to prolong the service lives of the active element (due to increase of the working pressure) and the commutator (due to the better load matching).

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