High-power high-beam-quality laser systems oscillating in visible spectral range on copper atomic self-terminating transitions

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Introduction

One standard application of lasers is in industry for cutting, welding, drilling, etc. of materials. The range of application of laser radiation is determined by the radiation properties as wavelength, power, beam geometry, divergence, etc. The precision of many operations done via lasers is concomitant of the so called beam quality.

Aims

1. To carry out comparative investigation on a 10-litre CuBr vapor laser, using monopolar and bipolar HV power supplies;
2. To develop Master Oscillator – Double-Pass Powerful Amplifier – Powerful Amplifier (MO–DPA–PA) oscillating in visible spectral region at 510.6- and 578.2-nm atomic copper lines with average output power of 15 W and Beam propagation factor of about 1.2;
3. By means of all-solid-state power supply based on the new innovative bipolar HV excitation scheme, to develop a compact table-top 20-W CuBr vapor laser.

Experimental setup

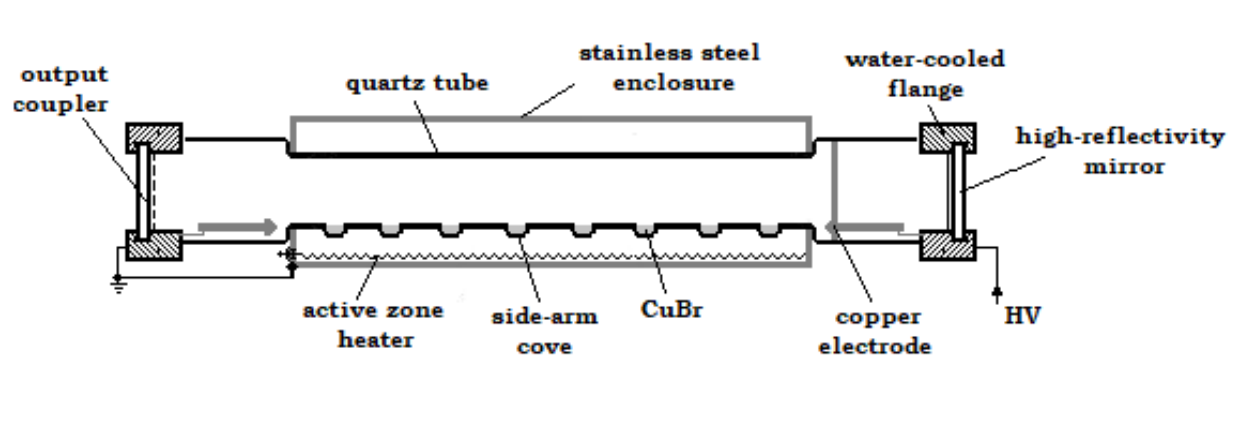

Fig. 1. Schematic diagram of investigated 10-litre tube.

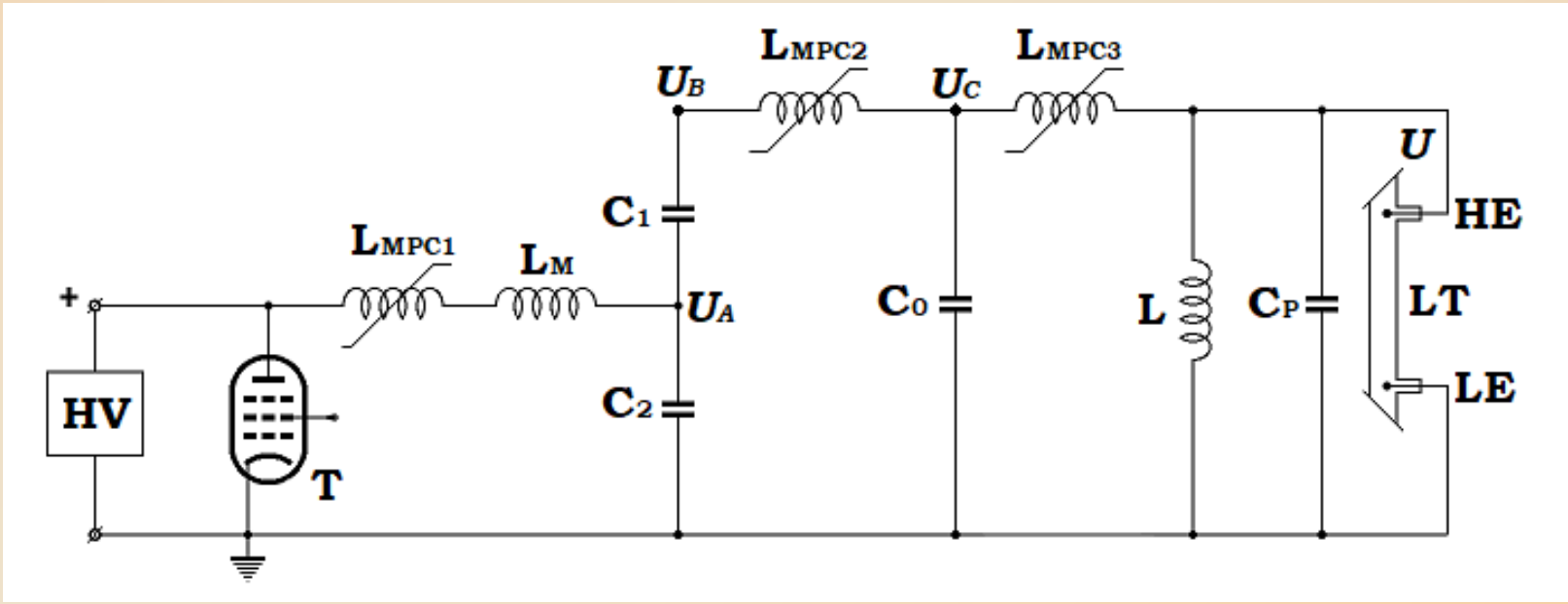

Fig. 2. Schematic diagram of monopolar electrical pulsed excitation scheme.

Experimental setup

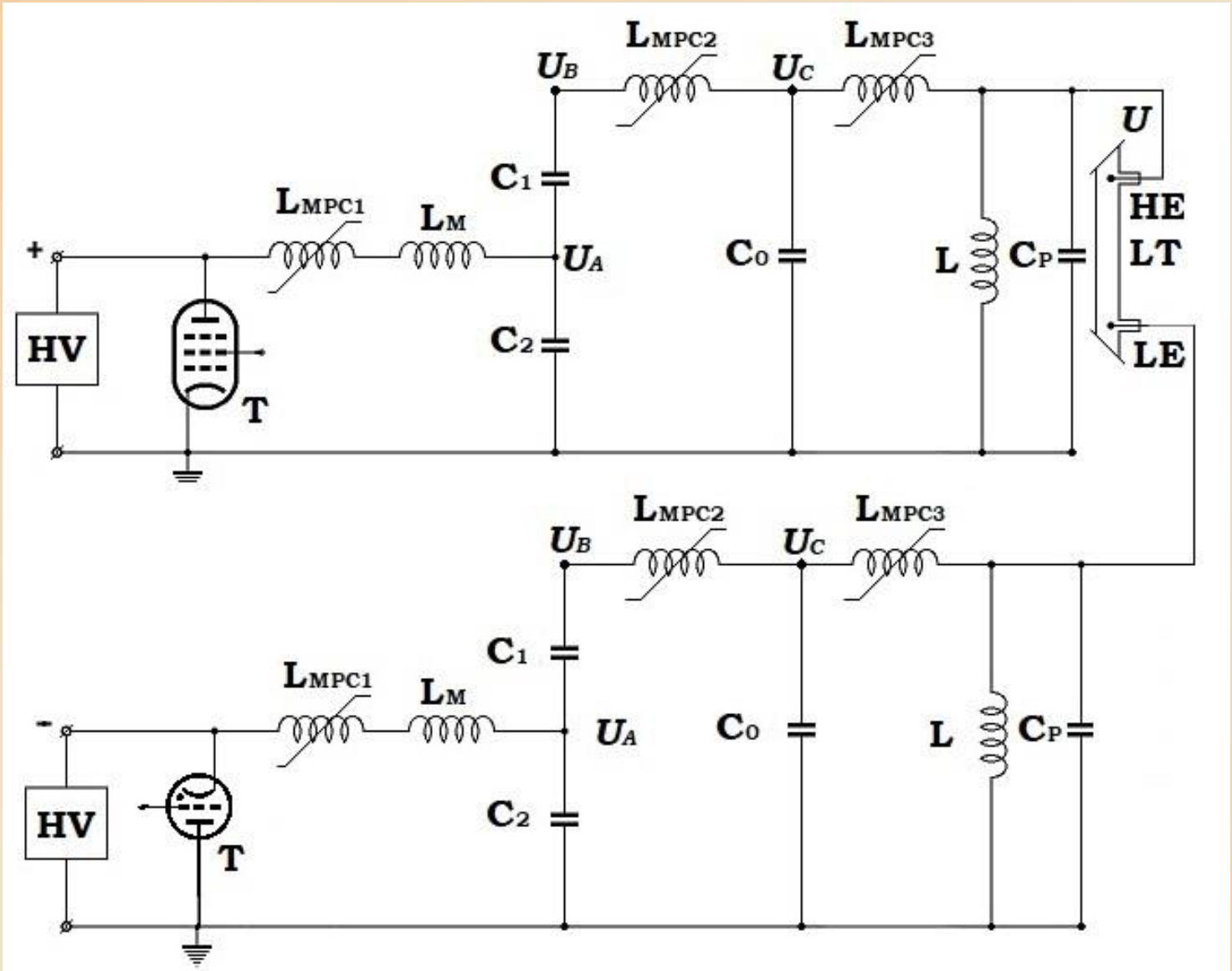

Fig. 3. Schematic diagram of bipolar electrical pulsed excitation scheme.

Experimental results

Table 1. $p_{H2\text{-}Ne}$ – H_2-Ne buffer-gas mixture pressure; C_{CB}^{*} – hot-value of the capacitor bank; C_0 – nominal-value of the capacitor separating the magnetic compressors; U_A – charging voltage of each of the storage capacitor banks; *prf* – pulse repetition frequency; P_{in} – average electrical power stored in each of the capacitor banks; P_{out} – average output power; η – efficiency (based on the stored in the capacitor banks).

p_{H2-Ne} (Torr)	C_{CB}^{*} (nF)	C_0 (nF)	U_A (kV)	*prf* (kHz)	P_{in} (W)	P_{out} (W)	η (%)
0.4 + 28.2	3.60	0.90	11.5	19.0	4523	85.56	1.89
0.4+ 28.2	3.60	0.90	12.4	19.0	5259	112.91	2.15
0.5 + 28.1	3.60	0.90	13.1	19.0	5869	130.28	2.22
0.5 + 28.1	3.60	0.90	11.5	19.0	4523	142.48	1.76
	5.22	1.45	8.5	19.0	3583		
0.5 + 23.3	3.60	0.90	11.5	19.0	4523	151.17	1.86
	5.22	1.45	8.5	19.0	3583		

Experimental setup

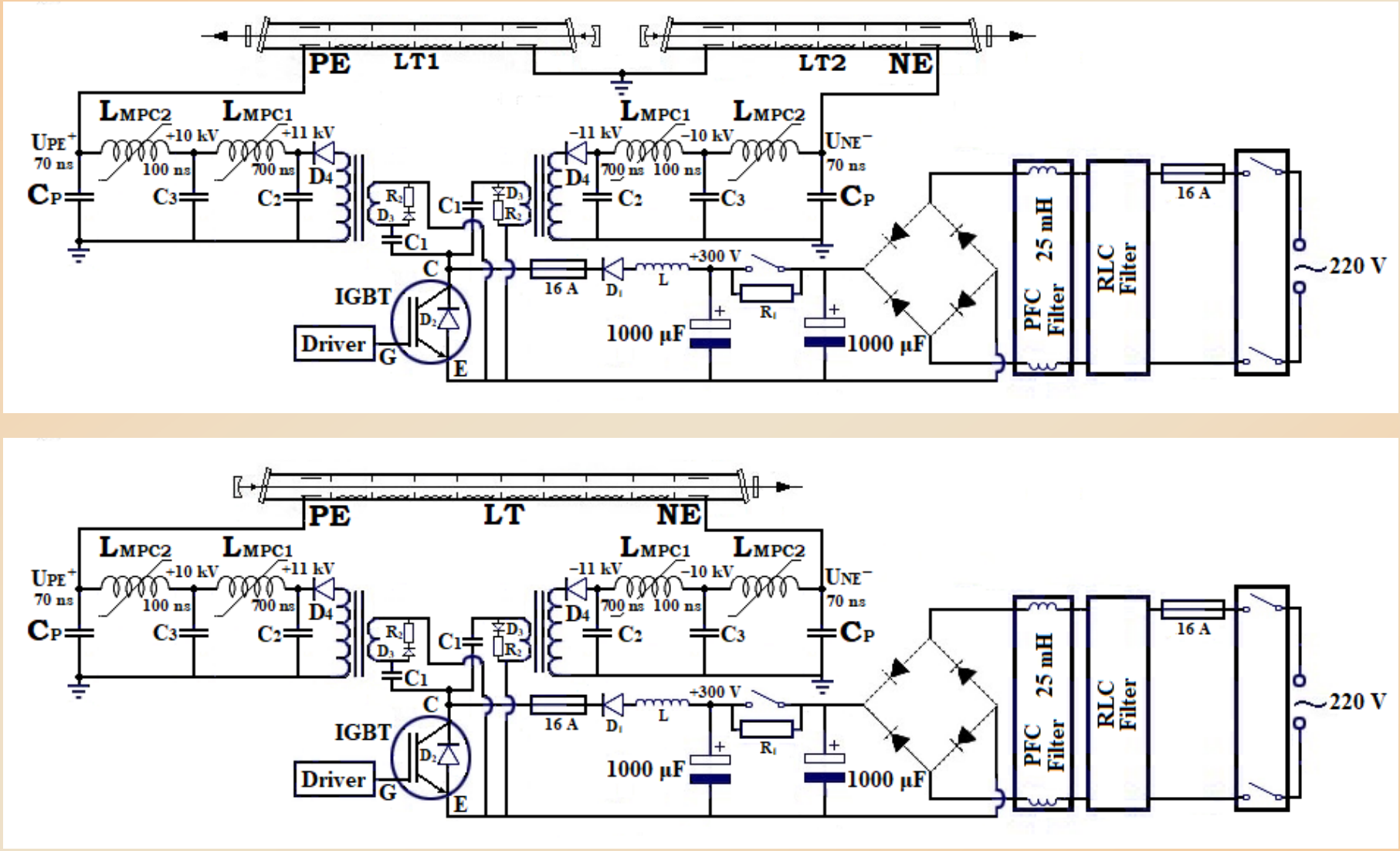

Fig. 4. Schematic diagram of bipolar electrical pulsed excitation scheme with one and two laser tubes.

MO–DPA–PA system

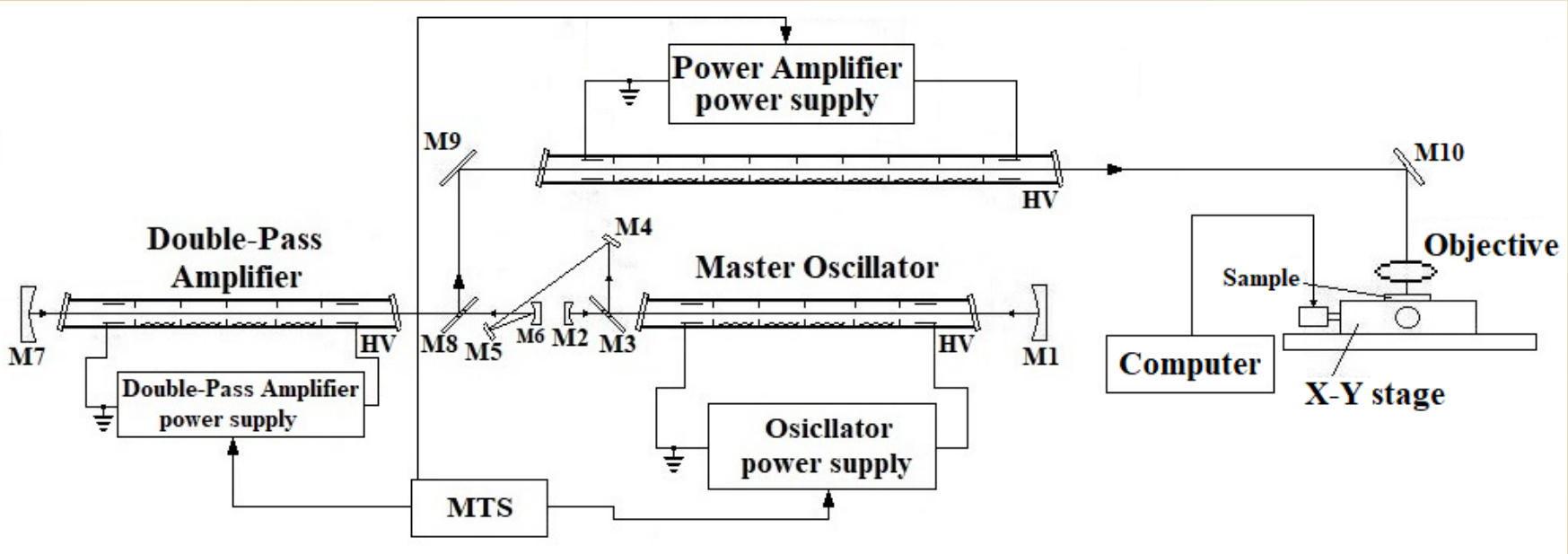

Fig. 5. Schematic diagram of MO – DPA – PA system.

Table 2. Parameters of optical elements, namely mirrors, lenses, diaphragms

Optics	M1	M2	M3		M4	M5	M6	M7	M8	M9	Objective
Focal length (cm)	115	6	∞	0.8-mm orifice	∞	∞	25	250	0.5-mm orifice	∞	6-100

Table 3. Electrical and laser parameters of MO–DPA–PA system

	C_1 (nF)	C_2 (nF)	C_{CB} (nF)	U_A (kV)	*prf* (kHz)	P_{in} (W)	P_{out} (W)	*Power fluence* ($W.cm^{-2}$)
MO	1.06	1.13	2.19	6.8	19.0	962	0.03	–
DPA	0.74	0.85	1.59	8.0	19.0	967	4	–
PA	0.98	1.05	2.03	10.0	19.0	1929	15	–
***f* = 6 cm**	–	–	–	–	–	–	–	$0{,}850.10^{12}$
***f* = 10 cm**	–	–	–	–	–	–	–	$0{,}306.10^{12}$
***f* = 40 cm**	–	–	–	–	–	–	–	$0{,}019.10^{12}$
***f* = 100 cm**	–	–	–	–	–	–	–	$0{,}003.10^{12}$

Conclusions

1. Be means of new innovative bipolar electrical pulsed excitation scheme a single-tube CuBr vapor laser produces the highest average laser power of 151 W for the atomic CuBr vapor lasers to date.
2. Extremely high fluence of peak pulse power of 0.3 and 0.85 TW per square centimeter is achieved with the MO–DPA–PA system at the focus of a 10-cm and 6-cm achromatic objective lenses.
3. By means of all-solid-state power supply based on the new innovative bipolar HV excitation scheme, to develop a compact table-top 20-W CuBr vapor laser.

Acknowledgements

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