A COMPACT DYE LASER FOR MEDICAL AND BIOLOGICAL APPLICATIONS

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This paper presents a description of a compact copper vapor laser based on a dye laser developed especially for medical and biological applications. The dye laser described is a light weight compact unit with an optical waveguide to deliver output radiation to irradiated targets. Exposure time may be prescribed and emission wavelength varied. Specifications of the LKM–02 dye laser head and LSI–01 spectral meter are given.

Different classes of lasers (gas, solid-state, semiconductor, and liquid) are now employed in medicine. They differ in their operating conditions and radiation wavelengths. Thus high-power continuous CO_2 and argon lasers, Nd^{3+}: YAG and excimer lasers with high pulse energy are all used in surgery to destruct (evaporate) and incise tissues. A particular application for low–intensity lasers is laser therapy. The most use here can be made of dye lasers capable of tuning to a required wavelength to achieve a good therapeutic effect. When designing such laser facilities specific operating conditions should be taken into account, namely, service requirements, the need to limit overall unit dimensions, to command a maximum tuning range in combination with control over the emission spectrum. A combination of Cu-vapor and dye lasers (CVL–DL) fully complies with the above requirements.

The system developed at the laboratory of laser physics and crystal physics at the Tomsk State University included an MLK–02 laser converter coupled to a Malakhit small–size Cu–vapor laser. The resulting device is extremely easy to operate and maintain, is reliable in servicing the laser converter, and operates efficiently at pumping power 300–500 mW. To achieve such a result itself the laser cavity losses were minimized, the laser was operated at high concentrations of active medium, and peculiarities of operating a Cu–vapor laser with a short cell were taken into consideration.

Figure 1 shows the optical flow–chart of the MLK–02 (Compact Laser Cell–02) resonator, as well as the mean generation power P_g in the maximum of the P6Zh (Rhodamine 6, Yellow) dye tuning range vs the pumping power P_p. Tuning ranges are indicated for the four dyes used. A minimum threshold level of pumping (below 100 mW) was attained at the 5–10% conversion efficiency.

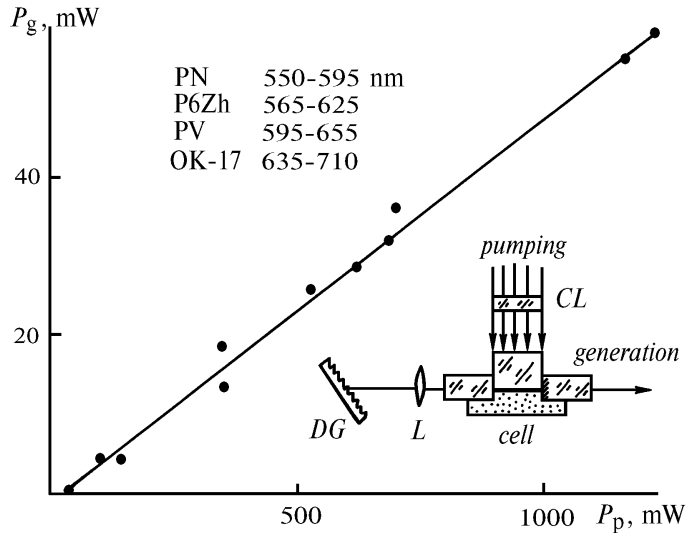

FIG. 1. Spectral energy parameters of the MLK–02 (Compact Laser Cell–02) laser converter. DG is the diffraction grating L is the lens, and CL is the cylindrical lens.

Radiation emerges from the converter to hit the target via a monofibre flexible optical waveguide. A control unit serves to prescribe radiation exposure and to remotely control the shutter. An interchangeable cell–pump makes it possible to rapidly change active medium in the laser converter without re-tuning the optical scheme. The MLK–02 (Compact Laser Cell–02) is constructed as a single piece unit, it does not require any control, and is extremely simple to use.

Operational wavelength is monitored by a LSI–01 miniature laser spectral meter (Laser Spectral Meter). It is built as a diffraction spectrograph. The dispersion element of the meter is a 1200 lines/mm diffraction grating. The objective has a focal length of 350 mm. To minimize the

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device a knee–bent "Z–shaped" optical train was developed. Radiation input was designed so that the wavelength could be directly controlled at the distal end of the optical waveguide. Both the wavelength and the beam spectral width were visually read off the instrument scale. The meter was calibrated against the pumping Malakhit–M laser which generates at 510.6 and 578.2 nm. To summarize, the instrument does not need any controls, does not require any special energy supply, and is easy to handle.

Given below are the specifications of the MLK–02 and the LSI-01 units:

MLK–02

Radiation wavelength, nm	550–710
Mean radiated power, mW	20–100
Pulse repetition rate, kHz	15–20
Pulse duration, ns	10–15
Spectral line width, nm	1–3
Exposures available, *s*	1–9999
Power consumed, W/V	150 (220)
Overall dimensions, mm	310×230×170
Mass, kg	7

LSI-01

Spectral range, nm	490–720
Linear dispersion, nm/mm	2.2
Resolution, nm	1
Wavelength accuracy, nm	±1
Overall dimensions, mm	185×170×50
Mass, kg	0.3

Note in conclusion that the MLK–02 laser converter coupled to the Malakhit Cu–vapor laser has passed successful tests in the Moscow City Hospital No. 2 where it was used for serial experiments in intravenous irradiation of blood.