

Metal-vapor laser tubes equipped with a hydrogen reservoir with long service life

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Among most serious disadvantage limiting the service life of CuBr vapor laser tubes is poisoning of a hydrogen reservoir with gases produced in a laser tube during operation. A new design of a hydrogen reservoir using selective diaphragms permeable only for hydrogen and thus eliminating the possibility of poisoning with various gases was developed. This design provides for and maintains optimal hydrogen pressure during the entire service life of a laser head.

It is known for a long time¹ that a small amount of hydrogen in a bulk of Cu vapor can be used to achieve improved parameters of a laser tube. In this connection, hydrogen is used in manufacturing high-power CuBr-vapor lasers with sealed-off laser tubes.² In laser tubes,^{1,2} the hydrogen pressure is determined by the amount of hydrogen letting in the tube before sealing. Because of the constant degradation of hydrogen in the tube, its pressure continuously decreases. For the time less than the tube service life determined by the tube design and the manufacturing technology, the hydrogen pressure decreases below the minimum accessible value, and the laser output power sharply decreases.

To restore the pressure up to the initial level, one should depressurize the tube and fill it with the dosed amount of hydrogen from an external source. In Ref. 3 hydrogen was delivered into the CuBr laser tube from a heated hydrogen reservoir (HR). The active element of such a reservoir was made of titanium (sometimes zirconium) and saturated with hydrogen during vacuum processing. At the temperature below 150–200°C, hydrogen in titanium is contained in the form of a hydride, which decomposes reversibly at heating up to high temperatures.

Specialists from Spektronika Ltd. Company (Bulgaria) have studied the peculiarities of operation of a HR housed in the CuBr laser tube described in Ref. 4. The obtained gain in the output power reached 1.5 times. However, it was found that the CuBr vapor laser tube equipped with a hydrogen reservoir possesses also some disadvantages. Thus, during the laser operation, titanium reacts with halogens and metal halogenides, as well as with gases emitted from electrodes and other tube elements, and this significantly decreases the service life of the tube. In addition, as the HR heater is turned off (after the laser is turned off), the hydrogen pressure in the tube decreases and, if the off time is long enough, all hydrogen is adsorbed by the HR. Because of HR heating lag, additional heating by its energy released in the gas discharge, and the finite rate

of hydrogen diffusion in the gas mixture, the hydrogen pressure in the tube restores gradually and reaches the value needed for establishing stable output parameters of the laser only in a certain, rather long interval.

To increase the HR service lifetime and stabilize the hydrogen pressure in the tube at the level providing for the nameplate output power and efficiency for the entire service life of the laser, a HR design has been developed and constructed to exclude the possibility of HR poisoning by gases contained in the tube and maintain the optimum hydrogen pressure during the entire service life.

Figure 1 depicts the design of a self-heating tube for a metal vapor laser. The tube connected to power supply 1 consists of a sealed off body 2 with the exit windows 3 and current supplies 4, electrodes 5, gas-discharge tube 6, metal vapor generators 7, selective diaphragm 8 with a heater 9 and the heater power supply 10, hydrogen reservoir 11 with a heater 12 and the heater power supply 13, as well as thermal insulation 14. The selective diaphragm is made of palladium or nickel, i.e., metals permeable at heating only for hydrogen or heavy hydrogen, what prevents other gases emitted from electrodes and tube elements, as well as halogens and metal halogenides, from penetration into the reservoir.

The laser tube operates in the following way. As the power is turned on, voltage pulses through current supplies come to the electrodes and induce repetitively pulsed discharge in the gas-discharge tube. Because of thermal insulation, the energy released in the discharge heats the gas discharge tube and metal vapor generators. As the gas-discharge tube and metal vapor generators warm up, metal vapor fills the gas-discharge tube inducing emission, and emitted radiation leaves the tube through the exit windows. The power supply of the HR heater turns on simultaneously with the laser power supply. Once the hydrogen reservoir warms up to the temperature corresponding to the optimal hydrogen pressure, the heater of the selective diaphragm

turns on. After the working temperature of the selective membrane is achieved, if the hydrogen pressure in a cavity housing of the HR exceeds the partial hydrogen pressure in a cavity filled with the mixture of an inert gas and hydrogen and housing of the electrodes, gas-discharge tube, and metal vapor generators, then the hydrogen pressure in the latter increases up to that in the former one, thus providing for stabilization of the hydrogen pressure at an optimum level. Once the optimal temperature of the metal vapor generator is achieved, the laser turns into the stationary mode of operation that is characterized by nominal (nameplate) output power. As the laser is turned off, the heater of the selective diaphragm is turned off simultaneously. After the time, during which the selective diaphragm passes into the state impermeable for hydrogen, the heater of the hydrogen reservoir turns off. Such a turning-off sequence of various units provides for maintenance of the optimum hydrogen pressure in the cavity filled with the inert gas and hydrogen and housing of the electrodes, gas-discharge tube, and metal vapor generators.

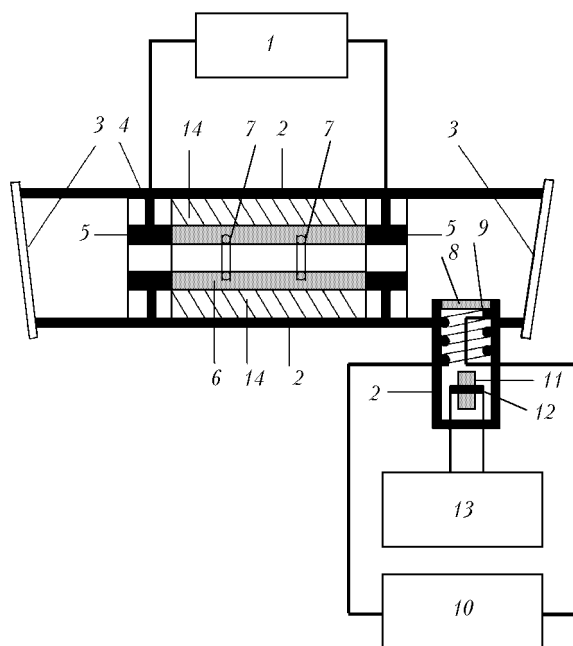


Fig. 1. Tube of a self-heating metal vapor laser.

The gain from using such a design is the increased service life of the laser tube and stabilization of the hydrogen pressure in the tube at the level providing for the nameplate level of the output power and the efficiency of the laser.

This technical solution can be used not only in laser heads, in which the needed pressure of metal or metal halogenide pressure is achieved due to self-heating, i.e., by the energy released in the discharge, but also in the heads of metal and metal halogenide vapor lasers equipped with external heaters. Besides, this technical solution can be used in other sources of induced radiation, which use hydrogen as the main or additional component of the active medium, for example, lasers operated at molecular hydrogen,⁵ neon,⁶ molecular nitrogen,⁶ XeCl and KrCl molecules,^{7,8} SF₆-H₂ mixture,⁹ lithium-type nitrogen ions,¹⁰ etc. Moreover, this solution can be used in sources of spontaneous radiation that employ hydrogen as a main or additional component of the active medium.

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