Powerful TEA Laser on Electronic IR Transitions of Rare Gases

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The goal of this work is the show of the prospects for a simple TEA laser excited by self-sustained discharge the same as a typical TEA CO_2 laser for generation of powerful pulses in rare gases (Xe, Kr, Ar, Ne) on IR electronic transitions. For this purpose the optimization of power and spectral parameters of such laser has been carried out. In result powerful lasing on about 15 lines in the range of 1 – 4 microns with output energy on stronger of them has been achieved >10 mJ (peak power >0.2 MW).

Lasers utilizing electronic transitions in rare gases are well-know. The most popular of them, helium-neon, has become a classical source of coherent radiation. Such lasers are characterized by high monochromaticity and frequency stability of radiation. However they have low output power. Output power grows by orders for pulse systems at high concentration of active medium. However for atmospheric pressures it is necessary to demand essentially more complex pumping techniques, for example, electron-beam-pumped systems, electron-beam controlled lasers.

In the present study, high-power coherent radiation pulses were obtained due to a conventional TEA CO_2 laser excited by a self-sustained discharge, which is widely used for lasing on vibrational-rotational lines of the CO_2 molecule [1]. The active medium was excited in the chamber of a TEA module representing a glass-fiber-reinforced epoxy cylinder with built-in electrodes and an ultraviolet preionization system. The dimensions of the active medium were 65×2.5×1.8 cm (~0.3 liter). The discharge circuit was supplied by two low-inductance capacitors with a total capacitance of 0.2 μF. The power supply system provided input of the pumping energy into the active medium within 0.4 μs. The laser cavity was formed by a nontransmitting gold-coated concave mirror (R = 5 m) and a Ge etalon. The cavity base was ~1 m. The output energy W of TEA laser in optimal mixtures was studied as a function of the total pressure p. As p increased, W increased linearly for all gases. However, the system used was not designed for high pressure. The trend of the dependences $W(p)$ and our analysis indicated that for this laser the optimal pressure p will be considerably higher than atmospheric and has to be 3-5 atm. It follows from estimates that at these pressures the output energy should be approximately trebled. Variation of the voltage across the storage capacitor Uc revealed a weak dependence (particularly for Xe and Ar) of the output energy on voltage. The output energy for Xe, Kr, and Ar was the highest at the same voltage of ~17 kV. As Uc increased, the total efficiency of the system (ratio of the output energy to he energy stored in the storage capacitor) decreased. The highest efficiency 0.2 % was achieved for Xe at Uc = 10 kV.

In a nonselective cavity we observed lasing in Xe for five lines. Under optimal conditions, the relative lasing intensity at the various wavelengths was: 1% at λ=1.73 μm, 51% at λ=2.03 μm, 6% at λ=2.65 μm, 34% at λ=3.44 μm, and 8% at λ=3.65 μm. Three lines were emitted from Kr: λ=2.19 μm (6%), λ=2.52 μm (47%), and λ=3.06 μm (47%). Three lines were also observed in the output radiation spectrum of Ar: λ=1.79 μm (2%), λ=2.21 μm (56%), and λ=2.4 μm (42%). Lasing in Ne was for mixture Ne:Ar:He=2:1:35 and the output energy was 0.4 mJ.

The results of investigations of the time parameters of the output radiation were carried out. For Xe and Ar all the lines were emitted at the leading edge of the pump pulse, indicating that the upper laser level was excited directly in the discharge plasma. The half-height duration of the lasing was ~60 ns for Xe. The spike power was some hundreds of kilowatts. These results are not the best obtainable. By optimizing the cavity and the pumping system, the output parameters can be improved. The appearance of the output pulse at the leading edge of the discharge current indicates that the pump power has to be increased to improve the output energy in this laser. Estimates show that by optimizing the excitation systems, the efficiency may be improved to 1%.

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