The physics and technology of cw RF-excited Ar-He-Xe laser with output power density of $0.5\text{W}/\text{cm}^2$

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Summary

The research interest in the Ar-Xe laser has been strengthened considerably because this laser produces now output powers on the level of Watts and is becoming the most promising light source in the wavelength region of a few microns. The lasing occurs on the IR transitions ($1.73 - 3.51\ \mu\text{m}$) between the $5d - 6d$ manifolds of atomic xenon. Our breakthrough in this type of laser came when our results obtained with the e-beam sustained technology showed the beneficial effect of operating at high gas densities. From these observations and the accompanying modeling the idea was supported to consider the dissociative recombination of ArXe^+ or Xe_2^+ molecular ions with electrons as the primary channel for filling the upper laser level. Apart from this recombination process by three body collisions the increased density leads to homogeneous line broadening which has also a favourable effect on the power and efficiency. However, a homogeneous inversion density requires a homogeneous discharge in a high-density gas. This is from a technical point of view a great challenge.

For continuous operation the waveguide structure with RF excitation has shown so far the best perspectives for maintaining a homogeneous discharge at high densities, say above 100 Torr. The RF discharges are characterized by thin positively charged layers (sheaths) near the electrodes. They play an important role in the stabilisation of the discharge. At increasing current density the discharge switches from α - to γ -mode.

In the γ -mode we are dealing with secondary electron emission from the cathode due to the increased field strength near the electrode. These strong fields are very effective in the kinetic chain of the laser process. This is clearly observed by the gain distribution between the electrodes. It is remarkable that the discharge of this laser can operate for the same input power either in the α -mode or in the γ -mode. The γ -discharge is visibly much brighter whereas the α -discharge has thicker sheaths and generates substantially lower output power. It may even occur in a certain region of input powers that along the discharge the medium is split up in alternating small regions of α - and γ -discharges. At higher input powers the γ -mode is stable and the output increases with the input power. The output power depends on the geometry of the waveguide or slab structure. For instance for a slab of $1.5 \times 10 \times 370\ \text{mm}^3$ an output of 1.5 W is obtained for an input of 300 W a 125 MHz. The specific output increases with decreasing gap distance between electrodes because of the fractional increase of the high field sheath region in the γ -discharge. At an electrode separation distance of 0.5 mm the specific output power is $0.5\ \text{W}/\text{cm}^3$.