High-energy HF (DF) Lasers based on Non-Chain Chemical Reaction

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Abstract

The formation of a scalable self-sustained volume discharge in strongly electronegative gases and the creation of wide-aperture high-energy non-chain HF (DF) chemical lasers. Expanding the generation spectrum of a non-chain HF (DF) chemical lasers and creating pulsed lasers with high energy per pulse and P-P lasers with high average power in the spectral range > 4.1 µm.

Introduction

Non-chain HF (DF) lasers are the foremost suitable and ecologically safe source of powerful and energetic coherent radiation within the 2.6-3.1 cm (HF laser) and three .5-4.1 cm (DF laser) spectral regions. Among the various methods of HF (DF) pulse and pulse-periodic laser creation suggested by our team under the guidance of Academician A.M. Prokhorov was self-sustained volume discharge (SSVD). It is well known that a SSVD can be established in a gas by creating a primary electron density that exceeds a certain minimum value nmin throughout the discharge gap. Various methods for the preionization of the gas within the discharge gap are developed for this purpose. Using these methods, primary electrons can for the most part be made directly inside the release gas, which in some cases causes difficulties within the foundation of the conditions fundamental for the arrangement of SSVD. For example, high voltages are needed for the formation of initial plasma when the preionization source and active medium are combined within the same volume, whereas preionization with ultraviolet radiation may be ineffective because of the strong absorption of such radiation in a medium. In the case where soft x-rays are used, it's necessary to make sure rigid synchronization of the x-ray and pump sources. In the mixtures of gases typical of CO2 lasers, electron losses thanks to the trapping process are relatively small at low values of E/p. The trapping coefficient is considerably smaller than the absorption coefficient of ultraviolet radiation for the same mixtures. In principle, it should be possible to make primary electrons at the density needed for the formation of a SSVD at a substantial distance from an ionization source, and then to transport the electrons to the gap by drift in an electric field. A SSVD formation method that works by filling the discharge gap with a flux of electrons drifting in an electrical field, without preliminary ionization of the entire discharge volume, was proposed and implemented by our team. This method also made it possible to determine a SSVD during a system with a strongly inhomogeneous field within the discharge gap.

Objective

A new form of SSVD Certain conditions should be met on the way to SIVD realization in dense gases, the following of which are the basic ones.

Primary electrons with number densities of no less than 106-109 cm_3 must be created within a gas volume through its preliminary ionization.

In the special case where SSVD is employed for laser excitation, which imposes tight constraints on the uniformity of the active medium characteristics over the working volume, the primary electron multiplication should occur in a uniform electric field, which is usually provided by special shaping of the electrode surfaces.

Clearly, the first condition cannot be observed in such a strongly electronegative gas as SF6 because of the great primary electron losses from electron attachment, except for in the special 'photo triggered discharge' mode, which, however, is ineffective for energy input into molecular gases because of the low over-voltages at the gap and, in the case of large discharge gaps and active medium volumes, it is not realized at all. With increasing laser aperture and discharge volume, the problem of how to meet the second condition also arises–there are technical difficulties regarding the fabrication of large-sized intricate-shaped electrodes and the rise of the discharge circuit inductance caused by a useless growth in the transverse size of the electrodes. It clearly follows from the improved analysis introduced over that the opportunities for the formation of powerful electric discharge non-chain HF (DF) lasers while following the known physical standards for framing SSVD in thick gases are constrained. Moreover, when starting from these principles, all attempts to create non-chain HF (DF) lasers with radiation energy of ~1 kJ and above seem to hold no promise. This seemed to control scientists' efforts to expand the vitality boundaries of non-chain HF (DF) lasers. Although there have been numerous works concerned with non-chain HF (DF) lasers, the radiation energy attained for them by 1996 was at the level of 10 J.

Conclusions

The increase of electrical energy produced via the increase in the generator's capacitance at a given maximum generator voltage should be followed by the growth of the discharge volume V as V~C3/2, where C is the generator's capacitance. On fulfillment of all these conditions, one should also try to maximally decrease the time period of the energy deposition in the discharge plasma. The maximum generation energies obtained for non-chain HF (DF) lasers in our experiments were 407 J (HF) and 325 J (DF), with electrical efficiencies of 4.3% and 3.4%, respectively. The active medium volume was ~60 l at an aperture of 27 cm. Such a laser with some extra equipment can be beat intermittent with a redundancy rate around 100 Hz, which is significant for acknowledgment of new arrangement of advances. Of characteristic interest is the issue of further expanding the laser radiation energy. The dependence of the output HF laser energy Wout on the energy Wp stored in the capacitors of a high-voltage generator. This figure reflects the data we obtained using setups with different volumes of active medium. This allows us to predict the possibility of further increases to the output energy of non-chain HF (DF) lasers through the creation of setups that operate at energy depositions above a few tens of kJ using the methods we developed during that very productive period of time.