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PULSED CHEMICAL HIGH PRESSURE LASER USING THE MIXTURE $D_2 + F_2 + CO_2$

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The chemical lasers most widely developed by now are based on reactions of halogens with hydrogen, the first being the hydrogen-chloride laser [1]. Most investigators gave preference to reactions with fluorine, which has the largest energy content [2 - 4]. A logical consequense of this trend is the use of the chemical reaction of hydrogen with fluorine for lasers [5, 6], wherein the chain effective for the laser operation is considerably longer than the chain of the reaction of hydrogen with chlorine. Work with such lasers, however, has revealed their principal shortcoming, namely the rapid relaxation of the excited molecules by interacting with deactivated molecules of the same type. A very fruitful approach to overcoming this difficulty was the idea of obtaining inverted population by transferring energy from the "hot" molecules obtained in the chemical reactions to the "cold" molecules. This idea, first suggested for chemical lasers in [7], was successfully realized by a number of workers [8 - 11]. The procedure of introducing the polyatomic molecule CO_2 into the $D_2 + F_2$ mixture turned out to be very fruitful: it made it possible to increase the chemical efficiency and the output energy of a pulsed chemical laser by approximately 10 times [12]. The success of the experiments performed with the mixture at low pressures [12] has enabled us to advance to experiments at higher pressures of the reagents. By introducing the CO_2 molecules we were able to obtain a working mixture in which the partial pressures of the deuterium and of the technically pure fluorine exceeded the second chain limit of ignition of the pure stoichiometric $D_2 + F_2$ mixture. CO_2 apparently eliminates the energy branching in the reaction between deuterium (hydrogen) and fluorine, without noticeably affecting the length of the direct chain[1]. A typical ratio of the partial pressures of the main components of the gas mixture (fluorine, deuterium, carbon dioxide, and helium) was respectively 1:1:4:11; the total pressure varied in a range of several hundred Torr.

The experiments were performed in a stainless steel reaction vessel. The reaction was initiated by radiation from a straight flash lamp with brightness temperature 20000 - 25000°K, wherein an electric discharge (20 μF, 30 kV) was initiated in a quartz tube by an exploding wire [13, 14]. The radiation was extracted through windows of sodium chloride, located in flanges of the reaction tube. The optical resonator was made up of a gold-coated flat mirror and one of the windows of the reaction vessel. Light passing through a sodium-chloride plate was directed to a calorimeter, and part of the light, after attenuation, to a gold-doped germanium photoreceiver operating at liquid-nitrogen temperatures.

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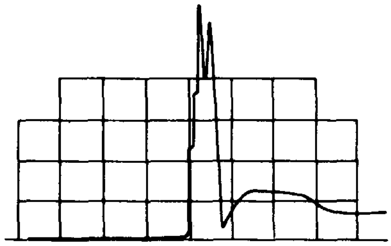
[1]We disregard here the possible role of CO_2 as a third body in reactions of the type $F + F + M \rightarrow F_2 + M$ and $D + D + M \rightarrow D_2 + M$.



Shape of generation pulse. Each horizontal division equals 10 μsec.

The experiment has shown that the rate of formation of the fluorine atoms upon dissociation of the fluorine molecules under the influence of the radiation from the employed source was in most cases insufficient to produce lasing. To improve the conditions for the initiation of the reaction, an easily-dissociating fluorine-containing component was introduced in the mixture, in the form of molybdenum hexafluoride or other fluorine compounds. The MoF_6 pressure (several Torr) was set to make the characteristic time of the chemical reaction about 1 - 2 μsec.

The figure shows the form of the emission pulse of the chemical laser at an approximate wavelength 10.6 μ. As a rule, lasing occurred 5 μsec after the start of the light pulse and lasted 7 - 10 μsec. Spikes of approximate duration 1 μsec were occasionally observed at the peak of the pulse. The energy in the emission pulse ranged from 5 to 15 J, depending on the composition of the gas mixture.

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DEVELOPMENT OF A CURRENT LAYER WHEN PLASMA MOVES IN A MAGNETIC FIELD WITH A NEUTRAL LINE

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Studies of the formation of current layers in a plasma are of interest in connection with astrophysics problems (solar chromosphere flares, the loop of