INITIATION OF DETONATION BY NANOSECOND GAS DISCHARGE

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The ultimate goal of this work is the obtaining of a small length of a deflagration to detonation transition under a minimum energy of an initiation. At the present work we studied deflagration-to-detonation control and direct initiation of detonation by non-equilibrium plasma of nanosecond gas discharge. The ignition of fuel mixture and flame propagation was observed after ignition by nanosecond gas discharge in the form of fast ionization wave. This type of discharge as a source of ignition has a set of advantages [1]: high spatial uniformity, high efficiency of formation of reactive species and coherence. The coherence is a simultaneous excitation of a mixture in a bulk volume. The released chemical energy in chemical reactions is enough for a direct initiation of a detonation at appropriate conditions.

The experiments were performed in a detonation tube with a diameter of 140 mm. The discharge device was attached to the detonation tube. The discharge chamber consists of a system of distributed electrodes, which provides uniform excitation at a length of 80 mm. In the experiments the high voltage electrodes were supplied with a positive pulse with an amplitude of 4-100 kV and duration at the halfwidth of 50 ns. Five IR detectors are placed along the detonation tube axis. Their sensitivity range is 0.9-4.6 μm. Initial gas parameters: composition, pressure and temperature were measured in the experiments. Besides, current and voltage of the discharge gap were measured. The flame speed was calculated from the signals of the IR emission.

We investigated the discharge development in our discharge device and flame propagation in the detonation tube. The experiments on initiation of detonation were performed in fuel mixtures: $2H_2+O_2$, $C_3H_8+5O_2$, $C_3H_8/C_4H_{10}+5O_2+xN_2$. The experiments were performed at a gas pressure of 0.2-0.4 atm. We observed the deflagration (Fig. 1), the transient detonation (Fig. 2) and the C-J detonation (Fig. 3). In the $C_3H_8+5O_2$ mixture at the initiation energy of 70 mJ L_{DDT}~ 90 mm, t_{DDT} = 0.6 ms.

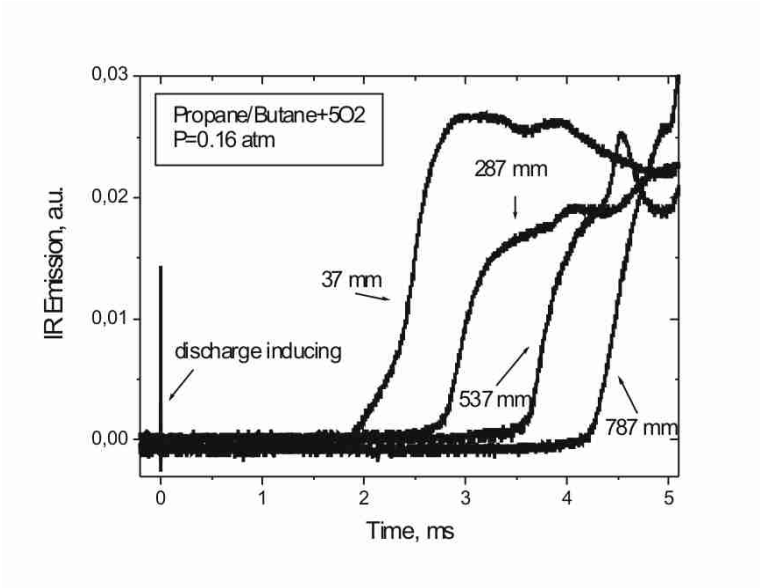

Fig. 1. Deflagration (v~300 m/s): IR emission from the flame front at different positions from the discharge chamber

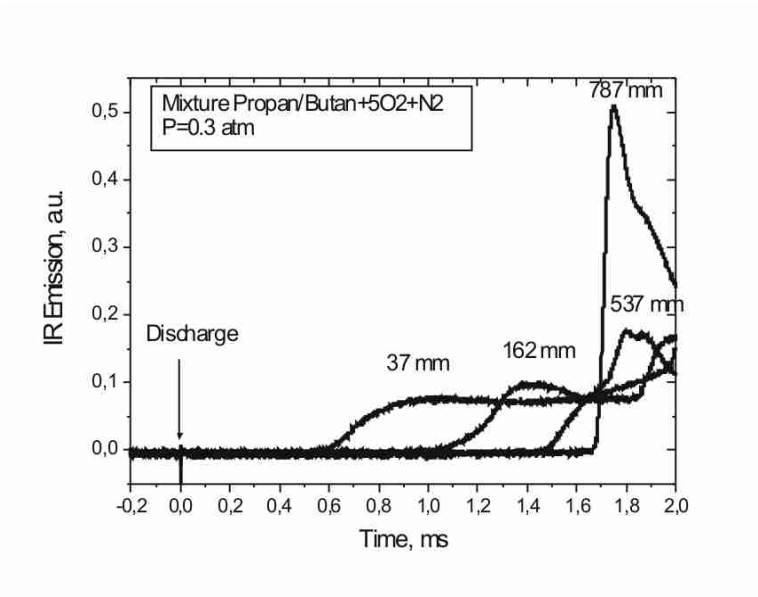

Fig. 2. Transient detonation (v=400 -- 2000 m/s): IR emission from the flame front at different positions from the discharge chamber

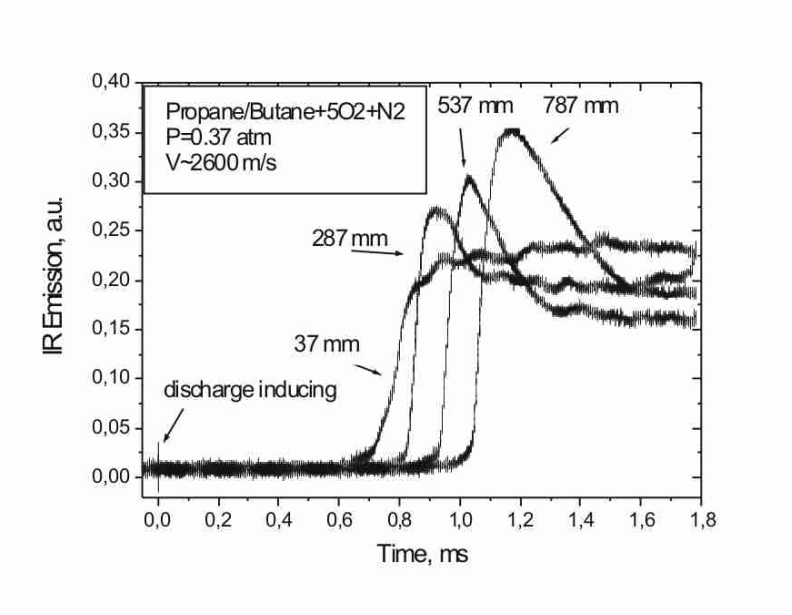

Fig. 3. C-J detonation (v – 2600 m/s): IR emission from the flame front at different positions from the discharge chamber.

Through the end plate of the detonation tube we carried out the observation of the discharge development and the formation of flame front. The observations were performed using ICCD camera La Vision Picostar 12 HR. The initial stage of the discharge is spatially quasi-homogeneous but in the subsequent stages the discharge is localized over the few sections of the high-voltage electrode. After exit of the flame from the discharge chamber the flame front is uniform through the cross-section of the detonation tube.

References

[1] Bozhenkov S.A., Starikovskaya S.M. and Starikovskii A.Yu., Combustion and Flame 133 (2003) 133-146.