High-Voltage electric breakdown of extended air gap guided by amplitude-modulated UV laser pulse

V.D. Zvorykin, A.A. Ionin, A.O. Levchenko, L.V. Seleznev, D.V. Sinitsyn, I.V. Smetanin, N.N. Ustinovskii, A.V. Shutov

P.N. Lebedev Physical Institute of Russian Academy of Sciences, Moscow, Russia, zvorykin@sci.lebedev.ru

Amplitude-modulated UV pulses generated by Ti:Sapphire/KrF laser GARPUN-MTW are combination of an amplified train of picosecond ultra-short pulses (USP) and 100-ns pulse of quasi-steady lasing [1]. The USPs possessing high peak power of 0.2–0.3 TW effectively ionize molecular oxygen in a multiphoton air ionization process, while a quasi-steady pulse maintain electron density in a plasma channel at the level of *ne* = (3÷5)·1014 cm-3 due to suppression of electron attachment to oxygen [2]. In the present experiments, amplitude-modulated pulses provided an electric discharge guiding along the laser beam between positively-charge sphere of 1.5-cm radius and grounded plane (Fig. 1). For a pulsed voltage amplitude of 420 kV laser-guided breakdown of the discharge gap with a length of *l* ≈ 70 cm was observed only for amplitude-modulated pulses with energy of 6.3 J. The breakdown development time depended on a time delay between the laser pulse and applied voltage. Its minimal value of *br* ≈ 0.6 s corresponded to the delay of *del* ≈ 0.8 s, although a laser-guided breakdown was also observed for longer delays of tens microseconds, which is higher than a lifetime of free electrons in laser-produced plasma channel (~10 ns) by several orders of the magnitude [3].

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| zvor.tif | **Fig. 1.** A layout of experiments and time-integrated images of the 70-cm length discharge for different delays between amplitude-modulated laser-pulse and HV pulse. |

Investigation of the breakdown development revealed that at laser triggering the velocity of a positive leader *vL* = 4,0×106 m/s was significantly higher than that in a self-breakdown regime *vL* = 1.2×106 m/s. When approaching to the grounded plane the leader accelerated up to 3.2×107 m/s, immediately after that a return stroke of the discharge arose which propagated with the velocity *vRS* = 6.7×107 m/s. The mechanism of the laser-triggered breakdown was suggested based on an acceleration of avalanche ionization process due to enhanced negative oxygen ions formation after termination of the laser pulse. Such ions have low binding energy of ~ 0.5 eV and a large lifetime ~ 1 ms.

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References

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