Surface-Launched Plasma Bullet and Its Application

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An atmospheric-pressure helium plasma jet (APPJ) caused by propagation of plasma bullets (or guided ionization wave) has been studied for a long time since it was first discovered by Prof. Engemann in 2005 [1]. Conventional plasma bullets are generally launched from the nozzle of a tube-type DBD of helium gas.

On the other hand, we discovered that APPJ-like plasma was generated from the glass-plate surface in contact with helium gas when a pulse high-voltage was applied to the opposite side of a glass plate as shown in Fig. 1. This APPJ-like plasma is formed by the propagation of plasma bullets launched like rockets from the surface of the glass plate. We have named this type of plasma bullets the surface-launched plasma bullets (SLPBs).

SLPBs were observed only when the dV/dt of the applied pulse voltage was sufficiently high. When the switching devices of the pulse power supply was changed from Si IGBTs (dV/dt = 36 kV/μs) to a SiC MOSFETs (dV/dt = 117 kV/μs, Nexfi Technology, Inc.), optical emission from the bullets became stronger as shown in Fig. 2.

Compared to conventional plasma bullets, which are limited to being launched from a narrow nozzle, the SLPBs may be launched from the wider surface. As a result, as shown in Figure 3, a large volume of plasma is obtained, of which the size is unthinkable with conventional low-temperature atmospheric pressure plasma.

The SLPBs were applied to hydrophilic treatment of the inside of a continuous porous dielectric. The results are shown in Figure 4. Conventional APPJ treatment did not sufficiently hydrophilize the inside, whereas SLPB treatment achieved sufficient hydrophilization of the inside.

In addition to the above experimental results, we disscuss the results of numerical simulations conducted to understand the reason for dV/dt dependence of the SLPB and to explore the possibility of shape control of SLPBs by electrode structure, together with experiments using less-expensive argon gas.

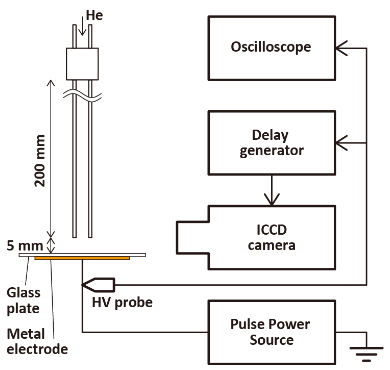

Fig. 1 Experimental setup for launching and observing SLPBs.

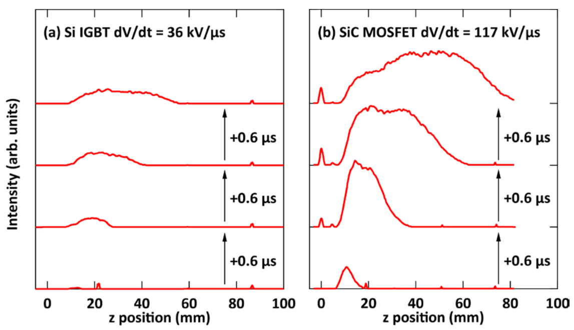

Fig. 2 Optical intensity of the SLPB driven by the pulse power source with Si IGBT (dV/dt = 36 kV/μs) and SiC MOSFET (dV/dt = 117 kV/μs).

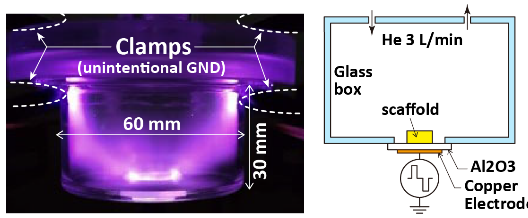

Fig. 3 Large-volume atmospheric-pressure plasma obtained by SLPBs in helium gas.

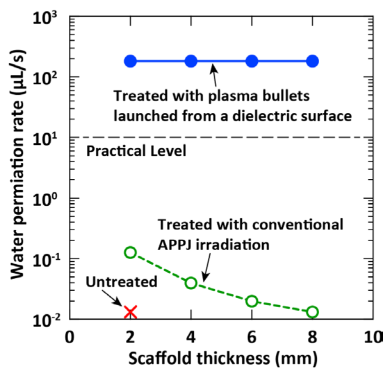

Fig. 4 Results of hydrophilic treatment of the inner surfaces of a continuous porous dielectric using SLPB and conventional APPJ.

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Reference

[1] M. Teschke *et al*, IEEE Trans. Plasma Sci. **33**, 310 (2005).