9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

dV/dt Dependence of Characteristics of Surface-Launched Plasma Bullet - A Study up to 356 kV/μs using SiC MOS FETs-

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It is known that a low-temperature atmospheric pressure plasma jet using helium gas is formed by the propagation of a localized ionization region called a plasma bullet. This plasma bullet is generally launched from the nozzle of a DBD using a glass tube and propagates through a helium gas jet effused into the atmosphere.

We have discovered a new form of plasma-bullet launch, the surface-launched plasma bullet (SLPB), in which the plasma bullet is launched from the flat surface of a glass plate [1]. We have previously investigated the dV/dt dependence as a basic characteristic using the experimental system shown in Fig. 1, and clarified that the larger the dV/dt, the stronger the optical emission intensity of the bullet [2]. This means that not only the magnitude of the voltage but also the dV/dt is an important manipulable factor for obtaining a high-density plasma bullet.

The experiments mentioned above were conducted at dV/dt lower than the maximum value of 36 kV/μs for Si IGBTs. In order to investigate the effects of dV/dt higher than that of Si IGBTs, we have begun to investigate the SLPB using a pulse power source using cutting-edge SiC MOS FETs (Nexfi Technology, Inc.) [3]. Figure 2 shows the voltage-rise characteristics of the power sources used in this study.

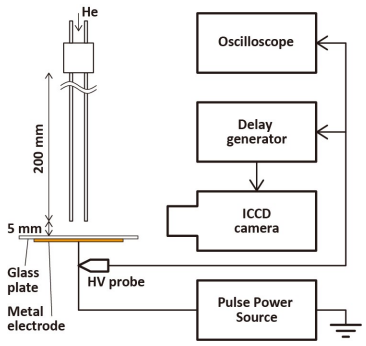

Fig. 1 Experimental setup for the observation of SLPBs.

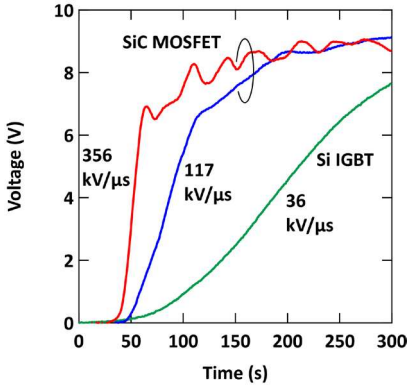

Fig. 2 Voltage-rise characteristics of the pulse power sources using Si IGBTs and SiC MOSFETs.

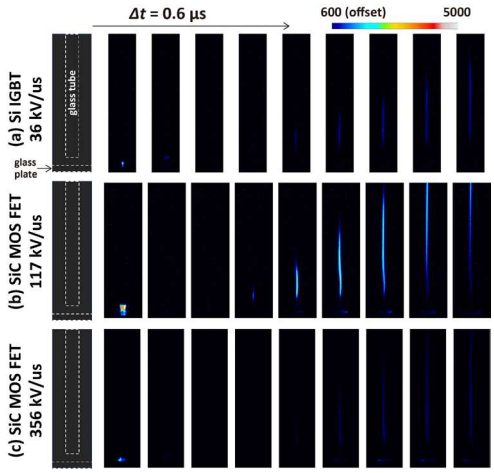

Fig. 3 ICCD images of SLPBs launched by pulse voltages with different dV/dt.

Figure 3 shows the results of ICCD images of SLPBs using the Si IGBT and two types of SiC MOS FETs. Compared to the SLPB using the Si IGBT with dV/dt = 36 kV/μs, the bullet obtained using a SiC MOS FET with dV/dt = 117 kV/μs shows a higher optical emission intensity as expected.

In order to achieve an even higher dV/dt, we improved our SiC MOSFET power source and achieved dV/dt = 356 kV/μs. However, in this case, the emission intensity decreased significantly. These results mean that higher dV/dt is not always better, and that there is an optimum value of dV/dt.

At present, we have not yet clarified the reason for the decrease in the optical emission intensity of the SLPB due to an excessively high dV/dt, but one of the causes may be an increase in dielectric loss in the dielectric components due to an increase in high-frequency components associated with the high dV/dt waveform.

Acknowledgements
This work has been supported by the MEXT/JSPS KAKENHI (23K25863, 24K21542), and the Joint Usage / Research Program of Center for Low-Temperature Plasma Science, Nagoya University.

Reference

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[2] A. Matsumoto et al, 84th JSAP Autumn Meeting, 22p-A309-7 (2023).
[3] K. Kuroda et al, 85th JSAP Autumn Meeting, 16p-P03-3 (2024).