An efficient spark gap switch design for low impedance nanosecond pulse generator

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A 50-ohm nanosecond pulse generator (NS-PG) which can generate high voltage pulses with duration of 5 ns and fast rise and fall times of 2 ns enables higher energy efficiencies of plasma processing. To enable the development of a high-power generator for high processing capacity in the applications such as water purification and exhaustgas treatment, a low impedance NS-PG with higher output current was investigated, and a low impedance (12.5-ohm) NS-PG was developed in the previous study.

The NS-PG consists of a microsecond pulse generation circuit as a charging unit, and a nanosecond pulse forming line(ns-PFL) based on a Blumlein configuration with a self-closing high-pressurespark gap switch (SGS). SF_6 gas filled the SGS, and the output voltage of the generator was regulated by varying its gas pressure.

For a low impedance ns-PFL, reducing switching inductance is important for high switching performance. In the previous design of 12.5-ohm NS-PG, a surface discharge SGS consisting of coaxial electrodes on cross-linked polyethylene was implemented. Although this design was effective for forming large current nanosecond pulses, it did not satisfy the theoretical output. Furthermore, the problem of saturating the switching voltage due to tracking was caused in long-time operation. This study focused on the SGS structure of 12.5-ohm NS-PG and it’s improvement. The center electrode radius of SGS was 45 mm; which was changed to 10 mm to increase electric field enhancement factor. Furthermore, dielectric wall was kept away from electrode to remove the tracking.

This paper presents the switching performance of several types of SGS in 12.5-ohm NS-PG. All of experiments carried out using a 12.5-ohm matched register. Results show that peak output voltage and output current of improved SGS was 16.9 kV and 1.42kA with short pulse width (< 10 ns) at 30 kV switching voltage. Especially,output current was 4 times higher than that of the 50-ohm NS-PG, and the switching voltage saturation problem was cleared.