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Meter-Scale Atmospheric-Pressure Microwave Plasma Using Sub-Millimeter-Gap Slot[1]

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Atmospheric-pressure pulsed plasmas have been given much attention because of its various possibilities for industrial applications such as surface wettability control, sterilization and so on. Among various atmospheric-pressure plasma sources, microwave plasma that is produced inside waveguide-slots is attractive because high-density plasma up to 10^{15} cm^{-3} can be easily produced along very long waveguide with light-weight and rather simple antenna configuration. So far, we have investigated plasma production inside slot of the waveguide and in this talk, elongation of the plasma up to meter-scale with newly-designed plasma source will be presented. In this study, two types of antennas are proposed to elongate the atmospheric-pressure microwave plasma. Firstly, array-structured slot design with a closed-end waveguide is adopted using X-band microwave (10 GHz). In this structure, slot antennas with a total number of more than 40 are positioned with $\lambda_g/2$-pitch along $\sim$1m waveguide so as to utilize standing wave inside the waveguide and to increase the electric field inside the slot. By optimizing the antenna design, arrayed microwave plasmas are successfully produced along $\sim$1m-length waveguide. The arrayed-slot structure, however, the plasma is not completely uniform along the waveguide and plasma density drastically decreases between two adjacent slots. To solve this, an alternative type of antenna that is free from the standing wave effect is designed. In this new-type antenna, travelling wave inside the waveguide with no reflection wave is realized by a combination of a microwave circulator and a ring-structured waveguide. By this transmission line, microwave power flows only to one direction and the average microwave power becomes spatially uniform along the waveguide. By using a single but very long slot up to several tens cm, very uniform plasma is produced along the slot. The result strongly suggests easy scale-up of the plasma source more than one meter that can be applied to surface modification of large-scale devices.

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