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高速度カメラを用いたE面とH面での303 GHz ミリ波放電構造の詳細計測
Measurement of the 303 GHz Millimeter-wave Discharge Structure in the Electric-field and Magnetic-field Planes with a High-speed Camera

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Introduction

Millimeter-wave discharge induced in gas has self-organized structure called filament or fish bone. The millimeter-wave discharge is categorized into the overcritical and subcritical conditions [1]. In the overcritical condition, the incident beam and the beam reflected from the plasma surface form a standing wave. The local intensity at the antinode of the standing wave exceeds the ionization threshold and the plasma is ignited. Therefore, the ionization front jumps by one-quarter of the wavelength (λ/4 structure). The plasma elongates along the electric filed vector and a discrete filamentary array is formed in the E plane [2]. In the subcritical condition, even though the beam intensity is much lower than the ionization threshold, the ionization front propagates toward the beam source.

In this condition, the plasma filament is formed in parallel to the wave vector and pitch size of the each filament is roughly 0.9 λ The ionization front propagation velocity was measured to the order of 102 m/s at 170 GHz which was close to sonic velocity [3-5]. However, the experimental date of the millimeter-wave discharge is limited especially for the subcritical condition, because currently, a gyrotron is the only device that can deliver such high power in this frequency range. Therefore, we observed the millimeter wave discharge at 303 GHz with high spatial and time resolutions using a high-speed shutter camera.

Experimental setup

Figure 1 shows the experimental setup. A parabolic mirror was used to ignite the discharge by focusing the incident beam. The radius and focal length of the parabolic mirror ware 50 mm and 18 mm, respectively. The total incident beam power was measured to 104 kW and the incident peak power density was estimated to 34 kW/cm^2. A flat mirror was installed at the angle of 45° under the focal point to observe both the E plane and the H plane.

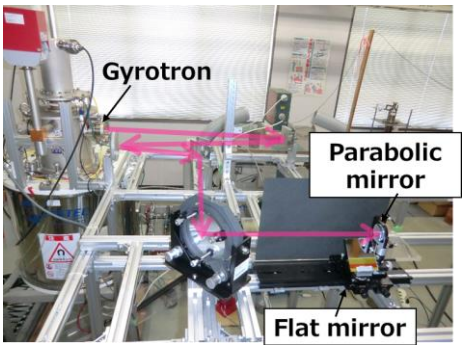

Fig.1 Experimental setup

Results and discussions

In the experiments, λ/4 structure was observed at the focal point of the parabolic mirror. The ionization front propagated to the mirror side. The filaments generated under the overcritical condition separates into granular plasmas under the subcritical condition. In the E plane, filaments are formed parallel to the wave vector. The average of the pitch size between filament was estimated to 0.96 λ. In the H plane, continuous plasma structure was observed.

Summary

The transition of the millimeter wave discharge from the overcritical to the subcritical condition is observed with a high-speed camera. The λ/4 structure was obtained at the focal point. After the ignition, the filaments separated into granular plasmas and in the E plane, filamentary arrays parallel to the incident wave with spacing of 0.96 λ ware observed.

References

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