27pC08

大気圧ミリ波放電におけるフィラメント構造の計測と数値計算
Experimental and Numerical Approach of Filamentary Plasma in Atmospheric Millimeter-wave Breakdown

[1]山口敏和, [1]武市天聖, [1]福成雅史, [1]小紫公也, [2]小田靖久, [2]梶原健, [2]高橋幸司, [2]坂本慶司
[1]YAMAGUCHI Toshikazu, [1]TAKEICHI Tensei, [1]FUKUNARI Masafumi, [1]KOMURASAKI Kimiya, [2]ODA Yasuhisa, [2]KAJIWARA Ken, [2]TAKAHASHI Koji and [2]SAKAMOTO Keishi

[1]東京大学大学院 新領域創成科学研究科 先端エネルギー工学専攻
[2]日本原子力研究開発機構 那珂核融合研究所 RF加熱開発グループ
[1]Department of Advanced Energy, GSFS, The University of Tokyo
[2]RF Heating Technology Group, Naka Fusion Institute, Japan Atomic Energy Agency

Introduction and Objective

In an atmospheric breakdown by a high-power millimeter-wave (MMW), an exposed picture of the plasma shows a filamentary line formation at a certain high power density beam condition (Fig.1). In previous studies the plasma was taken by a fast-framing camera, and the filamentary structure was formed by a propagation of many small particles of plasma[1].

In this study, atmospheric MMW breakdowns in some different conditions were generated, their images were taken by a fast-framing camera, and a numerical simulation was conducted, in order to investigate how and by what the filamentary plasma is formed.

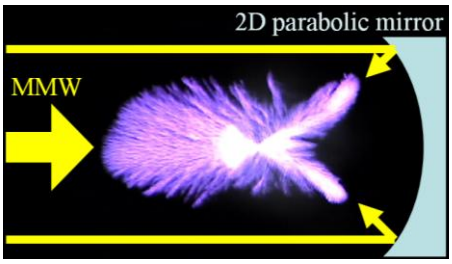

Fig.1 An exposed image of a filamentary plasma

Experimental approach of the filamentary plasma

A 170 GHz gyrotron was applied to generate a MMW plasma in atmospheric air at 570 kW using a focusing mirror. The beam waist diameter was 40 mm and the beam profile was converted from Gaussian into flat-top and ring shape using a pair of phase correcting mirrors. As a result, the granular plasma ionized at the powered area, and its propagation was dependent on the local power density distribution (Fig.2).

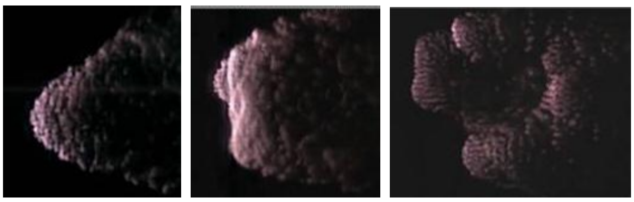

Fig.2 Images taken by a fast-framing camera (framing rate: 30 kfps, exposure time: 1.0 μs, left: Gaussian, center: flat-top from a side view, right: ring from a oblique view)

2-dimensional numerical approach

Several previous researches showed a field-parallel filamentary plasma at a higher power density in smaller area, and some numerical simulations were successfully applied to this kind of studies[2]. Therefore, a numerical approach by 2-dimensional symmetric FDTD method (Mur's 1st absorption boundary) combined with plasma fluid equation (1st extrapolation boundary) was conducted to simulate the experimental results (Fig.3). As a result, the steadily formed propagation of granular plasmas was obtained in H-plane (Fig.4). Granular ionization was generated by the interference of incident and reflected waves just forward to the plasma.

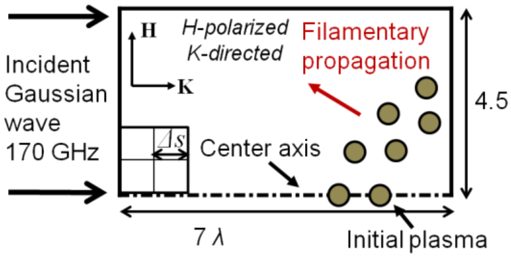

Fig.3 Calculation condition (grid space: $\Delta s = \lambda/170$)

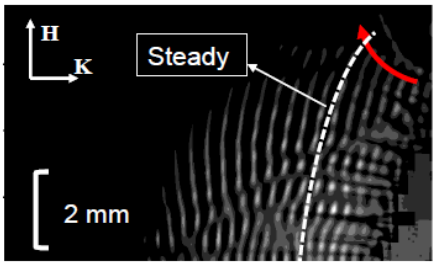

Fig.3 Calculation result of integrated traces in H-plane

Acknowledgements

This work was partially supported by Grant-in-Aid for JSPS Fellows (DC1, 2010-) and Grant-in-Aid for Scientific Research (A), No. 23246145.

References

1) Oda, Y. *et al.*: Plasma generation using high-power millimeter wave beam and its application for thrust generation, J. Appl. Phys., **100**, (2006), p.113308.
2) Boeuf, J.P. *et al.*: Theory and Modeling of Self-Organization and Propagating of Filamentary Plasma Arrays in Microwave Breakdown at Atmospheric Pressure, Phys. Rev. Lett., **104**, 015002, (2010).