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アークジェットプラズマ中の衝撃波のプローブ計測
Probe measurements of shock wave formed in an arcjet helium plasma

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When high-pressure gas expands through a supersonic nozzle into vacuum, barrel shocks and Mach disks with steep density and temperature gradients are generated [1]. A cell-shaped shock wave (shock cell) is also observed during the detonation initiating chemical combustion, in which the shock and combustion region propagate together. Recently, we found that the shock cell appeared in an arcjet plasma expanding through a supersonic conical nozzle [2]. The variation of the shock position in the residual gas pressure implied that the shock was formed by the collision of plasma and neutral particles in the expansion region [3]. In order to understand the mechanism for generation of the shock in the arcjet, the spatial distribution of plasma parameters (electron temperature and density) over the shock region is measured by electric probes.

Helium arc plasmas are generated between a cathode (2.4 mmϕ Ce/W rod) and copper anode. The plasma expands through a conical nozzle (anode) into the low-pressure region. A throat diameter and a divergence angle of the supersonic nozzle are 1 mm and 40°, respectively. The discharge current and voltage are I = 30–50 A and V_d = 30 V, respectively. The arc discharge is operated at ~1100 Torr. The pressure in the expansion section is kept to be ~10 Torr by using a rotary pump. Plasma parameters around the shock are measured by a Langmuir and double probes. The probe electrodes are cylindrical tungsten rods with a diameter of 0.5 mm and length of 1.0 mm.

For the Langmuir single probe measurement, no temperature variation is observed in the shock, while the steep density jump is obtained. Figure 1 plots the spatial distribution of the electron density, where the shocks appeared at 17 and 37 mm. This trend can also be reproduced by visible emission spectroscopy. On the other hand, the width (wavelength) of the shock cell calculated from the compressible gas flow dynamic theory is in good agreement with the experimental value. Therefore, the formation mechanism of shock in the arcjet could be explained by the simple gas dynamics.

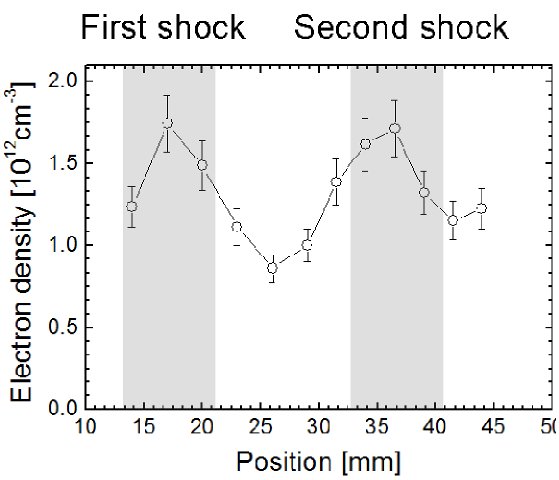

Fig. 1 Spatial distribution of electron density measured by Langmuir probe.

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