Some Fundamental Characteristics of Microwave Plasma Beam as a Heat Source (1)†

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Plasma production with microwave in an atmospheric pressure has been investigated by many workers[1)~3)]. They briefly refered to "plasma torch" stabilized by axial or tangential gas flow. With a microwave power up to 1 kW it is reported that a weakly ionized plasma in a local thermal equilibrium state is obtained and the electron temperature is below 1 eV.

While P. L. Kapitza[4)] has studied a fully plasma column produced in a cavity resonator at 1~3 atm. with a high power microwave generator of 175 kW, CW. He has succeeded in producing a fully ionized high temperature plasma ($T_e \simeq 100$ eV) in a steady state by circulating deutrium gas in the cavity. In this case maximum power absorbed reached 20 kW and the dimension of the plasma with a filamentary shape attained around 10 cm in length and 1 cm in diameter.

From these experimental results we have begun to study high power microwave discharge in a high pressure environmental gas over 1 atm. to obtain a stable high temperature plasma beam as a new type heat source.

In this report some fundamental characteristics of microwave torch-like plasma at a power level of 3 kW with a frequency 2.45 GHz are studied.

HF discharge is ignited at an open end of a coaxial wave guide where a water-cooled tungsten electrode is placed on the tip of the inner conductor. Plasma forming gas (N_2) is introduced axially into the wave guide with flow rate 50~200 l/min. Once started in this way the discharge is stable and the power reflection coefficient can be kept below 5 % up to 3 kW incident power.

With a CdS cell axial intensity distribution of light emission from a plasma is recorded on an X-Y recorder to obtain plasma length from its half length, L as illustrated in **Fig. 1.** The plasma length is proportional to the microwave power P_t and indicates around 10 cm at $P_t = 2.5$ kW. While plasma diameter is measured with a monochrometer from half width of the radial intensity distribution of H_β line spectrum obtained from mixing 5 % H_2 as a probing gas. The plasma beam attains 6 mm at $P_t = 2.5$ kW, $z = 1.5$ cm and it is also proportional to the microwave power. When a flow rate of the gas is increased, the plasma becomes slenderer and the power reflection coefficient smaller.

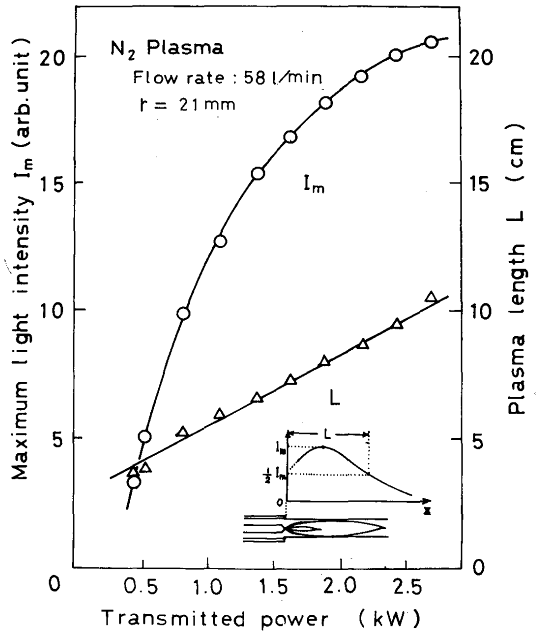

Fig. 1. Dependence of maximum light emission, I and plasma length L measured with CdS cell on microwave power. L is determined from half length of axial intensity distribution.

The flame produced by polyatomic gases (N_2, CO_2, air) has a stable figure and a small reflection coefficient, while a plasma produced from monoatomic gases (Ar, He) is not so easy to operate at high power ($P_t \geq 1$ kW) and has a large reflection coefficient. At high power the flash over between the outer and the inner conductors tends to appear for these gases.

Spectroscopic measurement with a monochrometer indicated that the intensity of hydrogen Balmer series lines did not show Boltzmann distribution. So that we don't at present obtain electron temperature and plasma density for N_2 plasma beam. Further careful

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and detailed investigations are expected in near future.

References

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