§10. Development of High Power Induction Plasma Device for PSI Studies Using MOSFET Inverter

Uesugi, Y., Tsubokawa, Y., Tanaka, Y. (Kanazawa Univ.)

We have been developing the arbitrary-waveform thermal plasma (AMITP) system using high-power MOSFET inverter power supply [1] for studies of plasma-material interactions. This system shown in Fig. 1 can modulate the coil current amplitude an externally-given arbitrary-waveform. The power supply of AMITP system consists of a rectifier circuit, an insulated gate bipolar transistor (IGBT) dc-dc converter (chopper) circuit and a MOSFET full-bridge inverter circuit. The amplitude of output rf current is controlled to the waveform of externally-given modulation signal by pulse-width modulation (PWM) control. The modulation signal is generated externally with programmable function generator. In addition to PWM control, the frequency of the MOSFET inverter is controlled to around 350-450 kHz by a phase-looked-loop (PLL) control to obtain load-impedance matching. The Ar AMITP induced by the modulated coil current is generated at a power of 30 kW at maximum in the present rf system. We studied to obtain fundamental characteristics of the AMITP system and the plasmas generated. The characteristics of AMITP system are the dynamic behavior of active power, driving frequency and load impedance. The characteristics of AMITP such as the radiation intensity of Ar spectral lines and the excitation temperature were measured by spectroscopic observation. Fig. 2 shows (a) the modulation signal, (b) the inverter output current in root-mean-square value, (c) the radiation intensity of the Ar atomic line at 714 nm, and (d) the Ar excitation temperature, in a triangular waveform modulation case.

The Ar excitation temperatures measured at different positions change from 8000 K to 10000 K similarly. At further downstream i.e. at position S, Ar excitation temperature changes from 5000 K to 7000 K. As seen above, the absolute value of the temperature decreases to downstream portions at any timing, whereas the temperature waveform are similar and the temperature fluctuation is about 2000 K at any axial observation positions, even at position S. It is also seen that the temperature at position P and Q has a peak value in 16 ms after transition from decreasing current to increasing current, while the temperature at position S reaches a peak in 17.5 ms after the transition. This means that temperature change travels from coil to downstream portion.

Now, we are developing a feedback control system for the induction plasmas by using DSP (Digital Signal Processer)[2]. This system controls the plasma temperature to follow the reference temperature by PID control of the inverter output using DSP.

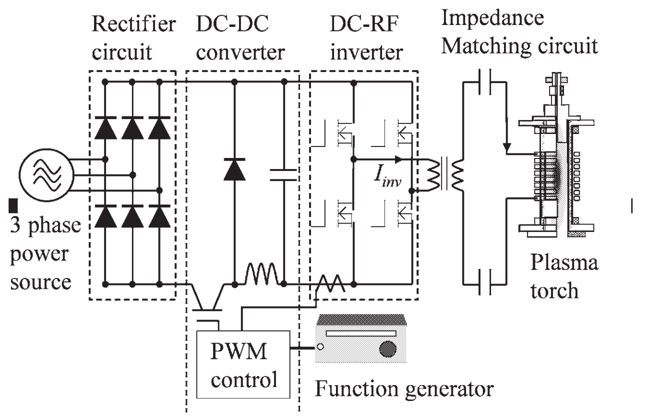

Fig. 1 AMITP system using MOSFET inverter.

1)Y. Tanaka et al, Appl. Phys. Lett 90, 2007,071502.

2) Y. Tsubokawa, Y. Uesugi, Y. Tanaka, Abstracts of ICPP 2008, EAP P3-158 G-E.

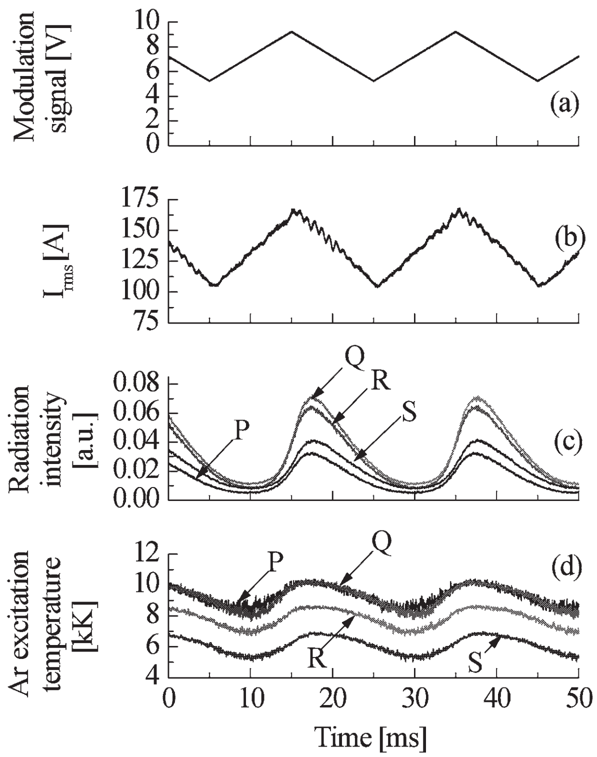

Fig. 2 Time evolution in (a) modulation signal, (b) the inverter output current, (c) radiation intensity of the ArI at 714 nm, (d) Ar excitation temperature from the two-line method. P, Q, R, S in the figure show the axial observation positions towards downward.