§24. Launch of the Comparative Study on Divertor-relevant Plasmas between MAP-II Divertor Simulator and GAMMA 10/PDX Tandem Mirror

Kado, S., Shikama, T. (Kyoto Univ.),
Sakamoto, M., Ezumi, N. (Univ. Tsukuba)

This work had been conducted prior to, and as a part of, the NIFS Bilateral Collaboration Project between University of Tsukuba (GAMMA10) and Kyoto University, "Assessment of the monitoring schemes for the gas injection experiment to divertor simulating plasmas"(NIFS15KUGM103).

In order to investigate atomic and molecular processes in fusion divertor/edge plasma as well as the plasma-wall interaction, steady-state linear plasma devices have been regarded as useful.

MAP (material(s) and plasma), originally designed as a single-chamber plasma-irradiation device was developed by Bolt and Tanaka in about 1990 [1] in the Tokai-mura site of the University of Tokyo. In 1999, MAP was modified to a dual-chamber device. From 2000, we had set targets of improving stability of the plasma discharge and developing and evaluating the various kind of diagnostic techniques. In 2002, the MAP-II was disassembled and moved to the Asano campus, in Tokyo. By that time, all two diffusion pumps had been replaced with turbo molecular pumps and the discharge power supplies (PSs) had also been replaced from an automatic, *i.e.* uncontrollable one for an arc welding, with a controllable stabilized power supplies combined with a variable ballast resister circuit, as shown in Fig. 1[2].

Plasma is started up with glow discharge using PS1 (250 V–20 A) and PS2 (350 V–20 A) in series. The plasma undergoes transition to arc discharge while increasing a discharge current and heating the LaB_6 cathode disk indirectly with tungsten filaments up to 400 W using PS4. PS3(180 V–75 A) is connected in parallel, which may absorb the plasma load variation and enables the stable operation current of 30 to 45 A.

Up to 2013, MAP-II experiments had been devoted to the diagnostic studies, such as; Fulcher-α spectroscopy for molecular hydrogen and hydrocarbon radical (CH) emission band spectroscopy, both of which can contribute to the molecular assisted recombination (MAR) processes; negative hydrogen ion measurement using a laser photodetachment (LPD) and its application to velocimetry (LPDV); Mach number probes; radiation trapping phenomena; development of Lyot-filter spectra camera for the imaging spectrometry; low-temperature laser Thomson scattering diagnostics aiming at the detached recombining plasmas, below 1 eV for MAR plasmas while below 0.1 eV for three-body and radiative recombination plasmas; the electron energy distribution function (EEDF) measurement.

A recent achievement is the application of Dopper-Stark spectroscopy for atomic helium lines. We have proposed measuring the line profile of several atomic helium spectra (He I) using a high dispersion monochromator, in which the contribution balance of Gaussian (Doppler) and Lorentzian (Stark) is different. Specifically, the transitions of 2^1S–3^1P (501.567 nm), 2^1S–7^1P (335.455 nm), and 2^3P–7^3D (370.500 nm) were found to be useful.

In the detached plasma for helium discharge in MAP-II where the volumetric recombination dominates, the temperature of the electrons, ions and atoms became close to each other (~ 700 K), suggesting the achievement of the *thermal equilibrium* around the gas temperature. In the ionizing plasmas, on the other hand, the temperature of the excited states of the atomic helium was reveled to be dependent on the states. This *disequilibrium* feature became more apparent as the electron density n_e increases (1300 K ~ 20000 K for $n_e \sim 10^{13}$ cm^{-3}) [3].

In the FY2013 MAP-II experiments in Univ. Tokyo came to an end, and it was relocated to Univ. Tsukuba in 2015. On March 30, 2016, we produced plasma successfully under low discharge current condition of 15 A without PS3, as shown in Fig.2.

The next step we take, after achieving the original performance with PS3, is to reinstall the diagnostics for the purpose of comparing the MAR processes in MAP-II [2] with those recently identified in GAMMA 10.

References
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[2] S. Kado *et al*., J. Plasma Fusion Res. **81**, 810(2005).
[3] S. Kado, J. Nucl. Mater. **463**, 902-906(2015).

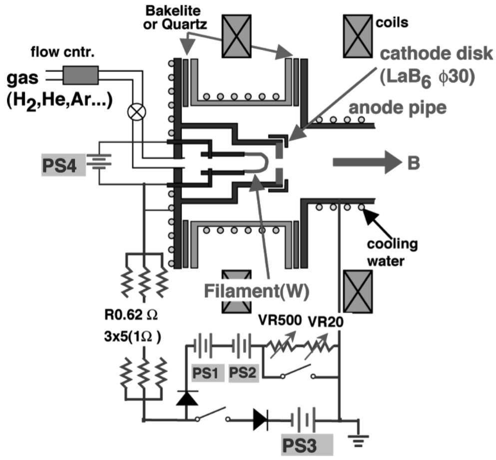

Fig. 1 Discharge circuit of MAP-II [2]

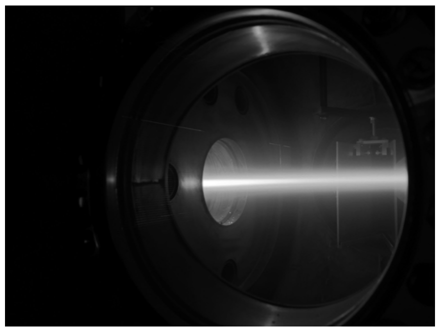
Fig.2 The first MAP-II Plasma in Univ. Tsukuba. Ar plasma 15 A in discharge current (30/Mar/2016).