4. Basic Research and Development

Research activities of the field of "Basic Research and Development" are strongly supported by the collaborations with researchers outside NIFS. In the fiscal year of 2009, 13 proposals were accepted in this field. The collaborations using plasmas produced in the HYPER-I device are the major part of this research activity. The HYPER-I device is the linear machine holding the plasma produced by the 2.45 GHz microwave in the continuous operation (CW). Basic plasma physics studies have been continued with the interests on the plasma flow formations and the vortex evolutions. Besides, because the steady plasma is very useful for the plasma diagnostics developments, a number of development works have been made using plasmas in HYPER-I device. A summary of works on HYPER-I device is given in the first report in this chapter.

For the understanding of the basic processes of particle interaction with nano-structure materials, the reflection of H^+ ions from the carbon nanotubes (CNT) was studied. The CNT sample was prepared with the chemical vapor deposition technique on a Si crystal-surface in a separate plasma chamber. Incident angle of H^+ is fixed at 8 degree and the incident energy was varied from 0.8 keV to 1.4 keV. Distributions of reflected particles with different reflected angles were measured. The broad peaks are observed at higher reflection angle side and they shifts to larger angle side with increasing the incident beam energy. It was considered that this dependence could be due to the reflection from deep places in the CTN.

Numerical simulations were made for the interactions of high-heat-flux plasmas with molecular gases involving dissociations and formation of molecular gases. Major interest of this study is for the physical understanding of the phenomena in the plasma torch device. Such modeling is also useful for the understanding of divertor region of fusion device where the molecular gas injection is programmed to mitigate the direct heat flux to the divertor plates. The mixture of Ar (98%), CH_4 (1%) and O_2 (1%) was analyzed. The plasma assisted combustion reactions between CH_4 and O_2 are also included in the simulation model, where as many as 200 reactions among 22 species of molecules and atoms are calculated. It was found that the electron temperature is close to the heavy-particle temperature at all calculated region except the region near the torch wall.

High-beta plasmas were produced in a cylindrical device (Large Diameter Device [LDD]) using the helicon wave. High-density plasmas close to 10^{13}cm^{-3} were produced in the low magnetic field (40 - 60 G), thus giving very high beta value of 0.8. The 7 MHz RF was launched with a spiral antenna and high beta plasmas were obtained with 2 kW power. The dependence of plasma beta on the gas filling pressure and the magnetic field was investigated. The 5 mTorr gas pressure gave the optimum condition for the high beta plasma production. Because the plasma production using the helicon wave does not have a sensitive dependence on the magnetic field strength, weaker magnetic field generally gave higher plasma beta. The local magnetic field strength was also measured for confirming the diamagnetic effect of plasma beta. The results showed smaller decrements of the field than the simple expectation. A candidate of the interpretation for the unexpected value of the local magnetic field is proposed.

An arc plasma with He gas at the atmospheric pressure was produced using a needle-shaped cathode and the combination anodes having a nozzle. In order to take the 2D emission profile of thermal arc plasmas, anodes are designed in rectangular shape with converging and diverging nozzle angles similar to the ones in the Laval-type nozzle. The discharge parameters are 50 A and 20 V. From the 2D images observed with a visible spectrometer, the profiles of electron temperature and density were obtained. By comparing the observed spectra of the continuous emission with the theoretical bremsstrahlung curve, electron temperature of 0.18 eV was obtained. The cooling of the plasma due to the adiabatic expansion in the diverging part of the anodes was confirmed from the spatial profile of the measured temperature. The Stark broadening of He atom line (667.8 nm) was measured for the density evaluation, and the density of 4.0 $\times 10^{15}$cm^{-3} was obtained and the linearly decreasing density profile was also obtained.

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