§43. Measurement of Space Potential Fluctuation in Edge Plasma of the LHD by Using Emissive Probe made of Carbon Material

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The investigation of heat transport in SOL plasma to plasma-facing components is one of the most important issues in edge plasmas of fusion devices. Sheath formed on the material surface regulates the plasma heat flux onto the plasma-facing components. When the plasma-facing components are heated up by the plasma heat flow to high temperature, thermoelectron emission occurs to reduce the sheath voltage between the plasma and the material surface. The degradation of the thermal insulation due to the reduction of the sheath voltage enhances the electron heat load onto the material surface. This positive feedback leads to hot spots on the surface.

Precise evaluation of the electron emission current is quite important in order to estimate the heat load onto the material surface. As the surface temperature is raised, the emission current goes up with temperature. The temperature limited current can be described by Richardson-Dushman(R-D) formula. Finally the electron emission from the material surface is quite large, the emission current may be regulated by space charge effect in the sheath region. In plasmas, a recent theoretical work gave new formula to describe the space-charge limited current for not only floating voltage but also arbitrary sheath voltage[1], which has been evaluated in the experiment which used tungsten target [2].

Carbon is still one of the most important materials as plasma-facing components. However, there is no systematic study on the thermoelectron emission from carbon surface in plasmas relevant to the divertor plasma condition. On the other hand, in emissive probes to measure space potential in plasma, tungsten is used as a thermoelctron emitter. One may, however, worry about the degradation of fusion plasma performance due to impurities coming from the melted tungsten tip. If carbon is found to have sufficient thermoelectron emission property in plasma, carbon can be employed as the material for the emissive probe in order to avoid severe contamination due to the impurities. In this study, in order to make the validity of carbon as the emissive probe material, we made a systematic study on the thermoelectron emission from carbon material in high helium and hydrogen plasmas.

The experiments have been performed in the liner plasma device Nagoya University Diverter Simulator II (NAGDIS-II). Carbon rod with a diameter of 3mm and a length of 2mm was irradiated by high density helium plasmas to be heated up. The surface temperature can be controlled by changing the applied voltage waveform to the carbon rod. Figure 1 shows the current- voltage characteristics measured by the carbon rod at the surface temperature of 1860 K (cold) and 2924 K (hot). This figure clearly shows the large thermoelectron emission current as 2924 K. Figure 2 shows electron emission current from the carbon rod as function of the surface temperature. Solid line indicates thermoelectron emission property of tungsten material. Fitting the experimental data with R-D formula gives a Richardson constant (8.1×10^3 A /m^2K^2) and a work function (3.6 eV). These experimental results showed that carbon is much better thermoelectron emitter rather than tungsten.

Reference
[1] S. Takamura, M. Y. Ye, T. Kuwabara and N. Ohno, Phys. Plasmas 5 (1998) **2151**.
[2] Y. Hagino, N. Ohno, S. Takamura, M. Y. Ye, J. Nucl. Mater. **313-316**(2003)675.

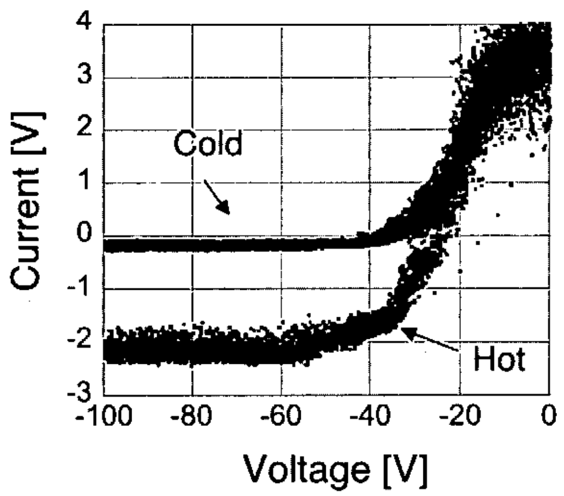

Fig 1. Current-voltage characteristics measured by cold and hot graphite probe in helium plasma.

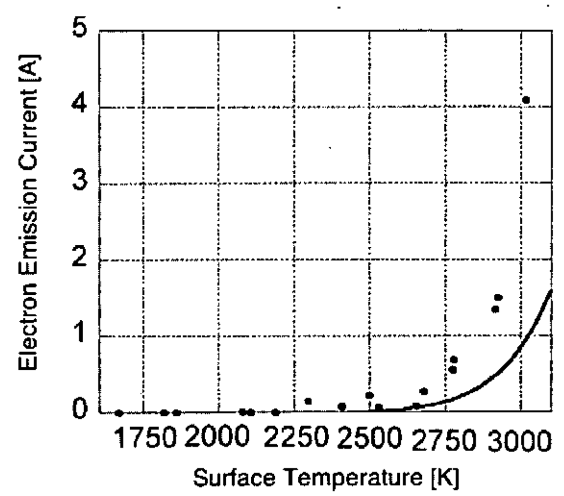

Fig 2. Electron emission current from carbon rod as a function of the surface temperature. Solid line indicates thermoelectron emission property of tungsten material.