Measurement of the ion reflection rate of carbon surfaces

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Introduction

It is very important to understand plasma-surface interactions for a fusion reactor because of the confinement and stability of the main plasma. In particular, the interactions between the dense, low temperature plasma and the divertor tile (carbon tile) are very important to realize the gas divertor and the remote radiative cooling.

In divertor region, the surface structure of the plasma facing materials (PFM) changes due to plasma-surface interactions. Therefore, it is reasonable that the ion reflection rate and also the secondary electron emission rate of the surface must changes with plasma-surface interactions. These rates affect the plasma sheath potential and as the results they affect plasma-surface interactions. Thus, a good place to start is the investigation the plasma-damaged surface of the PFM.

In this paper, first the surface fractal dimensions was applied to evaluate the surface structure of plasma-damaged PFM (Carbon). Second the relation between the surface fractal dimension and a low energy ion reflection are investigated.

Experimental setup and plan

The surface fractal dimensions were measured by the various method.[1-5] In this study, a convenient flow-type adsorption apparatus was developed to evaluate the surface fractal dimensions of the materials. The schematic of this device is shown in Fig.1. Four alcohol molecules with different apparent diameters were used as the probe adsorbates. The monolayer capacities of the samples for alcohol were determined by BET theory. The surface fractal dimension was calculated using the monolayer capacities and molecular area.

Figure 2 shows the surface fractal dimensions of the hydrogen plasma-damaged PFM Carbon (B_4C coated isotopic graphite, EBIDEN) measured by the adsorption method. The plasma of 2-3eV, $1.0\times10^{10}cm^{-3}$ is generated by DC discharge. In Fig.2 apparently the surface fractal dimensions are close to 3 with increasing the plasma exposure time. Therefore, the irregularity of the surfaces probably increase with plasma exposure.

The increase of the surface irregularity (or in these measurement the adsorption site may increase) must be related the ion reflection rate, and, the information of the first layer atoms of the surface may be taken by the low energy ion reflection (Ion Scattering Spectroscopy). For this aim the ion reflection measurement system is developing now. The schematic of this apparatus are shown in Fig.3. The ion source design[6] is based on the gaseous

DC arc discharge without magnetic field because the temperature of the source plasma is very low. Thus, the energy spread of the ion beams will be small. The energy of the ion beam ranges 500eV to 2.5keV. However, it can lower several eV by adding the decelerator. The current is expected up to 20μA, and the ion species is selected by the velocity filter.

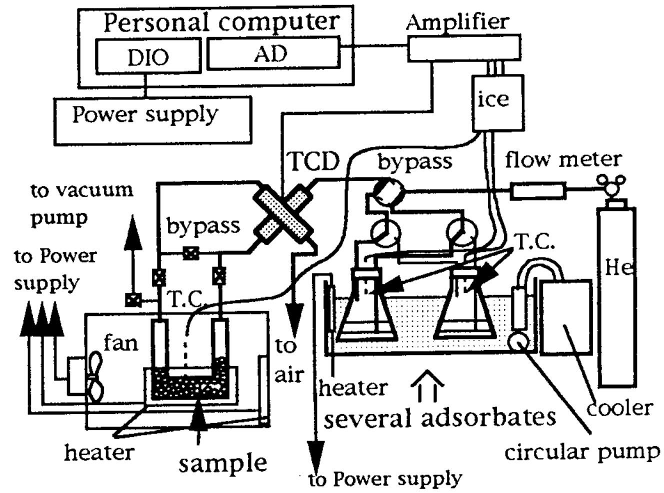

Fig.1 An automatic flow-type apparatus

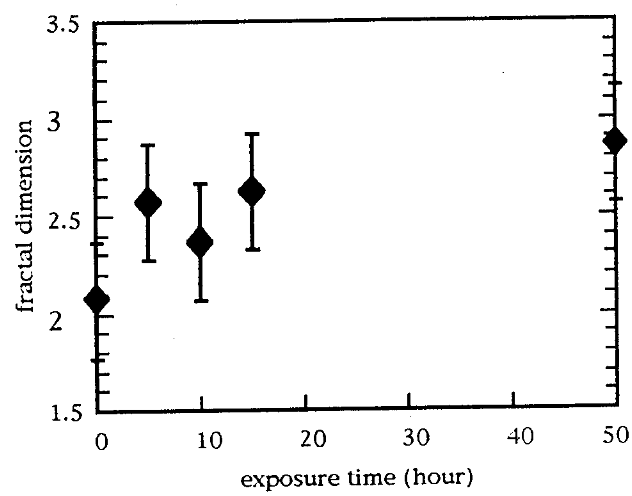

Fig. 2 Change of the surface fractal dimension of B4C with plasma exposure time.

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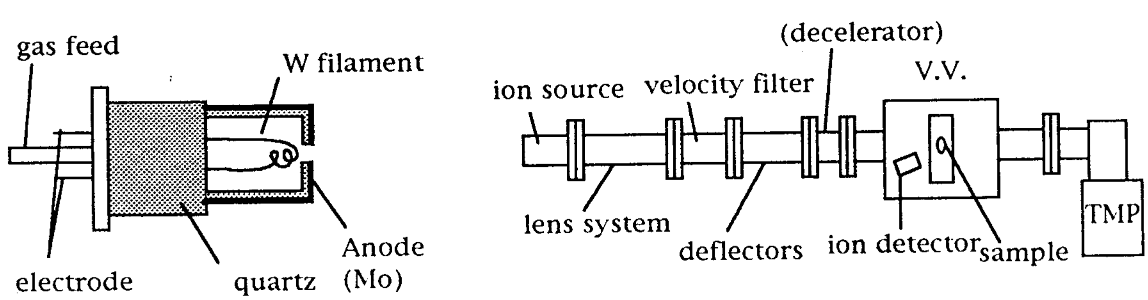

Fig.3 Ion source and ion reflection measurement system