§35. Structural Analysis of Carbon Co-deposited Layer in LHD

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An estimation of retained hydrogen isotopes in plasma facing material and deposition layer are important issues in ITER and Demo reactors. Carbon-based materials (CBMs) are still one of the candidate and favorable for fusion applications because of a low atomic number, good thermo-mechanical properties, low coefficient of thermal expansion and the absence of melting. But high T retention in Carbon-based materials are serious problem in ITER. In particular, carbon is known to take different structures, such as graphite, amorphous, diamond, with different characterizations. In this study, using different type of carbon deposition layer were made in LHD, there structural analysis were done by Raman spectroscopy and X-ray photoelectron spectroscopy (XPS).

Target samples made by SUS316 and Si were installed the section 6.5 at inner poloidal cross-section in LHD. These samples were set in the different facing holder and mainly two kinds of group can be separated facing samples, namely S1 and S2 and not facing samples, namely S3 and S4, to graphite divertor targets. A different point of S1 and S2 is the viewing angles from samples to divertor target.
Raman spectroscopy is sensitive to the graphitic structures (phonon distribution) and has been applied in order to study the structural changes of CBMs. Various CBMs, e.g. fine grain graphite, pyrolytic graphite, diamond, CFC, glassy carbon, were characterized.

XPS shows chemical bindings with depth profile using Ar ion etching. Carbon intensity can be separated by fitting analysis and the main carbon peak was calibrated by experimental results using Highly Oriented Pyrolytic Graphite (HOPG). The top surface of HOPG was peeled off to reduce surface contaminations and lower surface layer was used a calibration analysis.

The Raman spectra from the target samples exhibit two clear peaks, which correspond to the graphite peak (G peak) around 1580 cm^{-1} and the disordered peak (D-peak) around 1355 cm^{-1}. Figure 1 shows the shifted G-peak position vs Raman intensity ratios (ID/IG). All data show the amorphous like structure. Plotting data are separated two groups, one is the S2 & S3, and the other is the S1 & S4. The situations of samples exposed to diverter plasma and targets are separated S1 & S2 and S3 & S4, but the result in Fig.1 shows different characterization.

Figure.2 shows the atomic concentration of deposition layer on target S2. Main composition is carbon of 80% and a few amounts of O, Fe, B are observed. As the sample data of carve fitting analysis, a chemical binding energy of carbon is shown in Fig.3. Mainly three kinds of peaks, sp2, sp3 and CO of C1s were set for fitting analysis and the sp2 satellite peak was negligible. From a comparison of raman spectrum and XPS, the ratio of sp2 to sp3 is different. Because, the depth resolution of XPS is sensitive as shown in Fig.2, but raman data shows integrated intensities in deposition layer of a few 100nm.

Quality of fitting analysis for C1s binding energies is different on S1 and S2. Data on S2 at different depth positions by XPS could be done using the same fitting parameters, but S1 could not be done. The reasons are considered different compositions and hydrogen concentrations and then carbon structure is also different.
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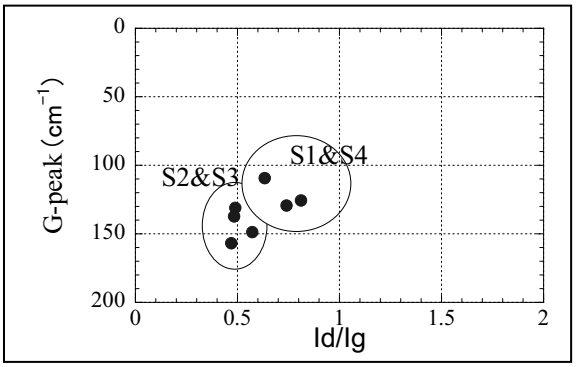

Fig.1. Variation of Raman intensity ratios (ID/IG) of target samples vs. shifted G peak position of graphite by Raman spectroscopy.

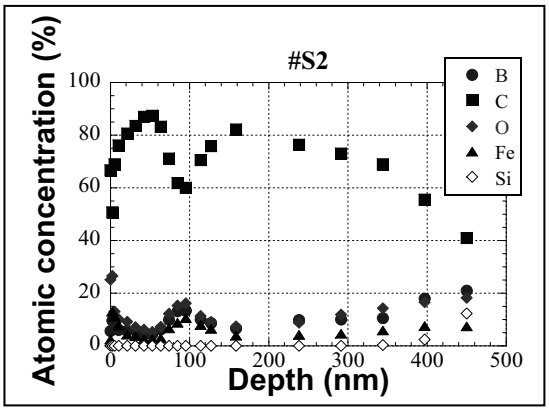

Fig.2. Atomic concentration of deposition layer on sample S2

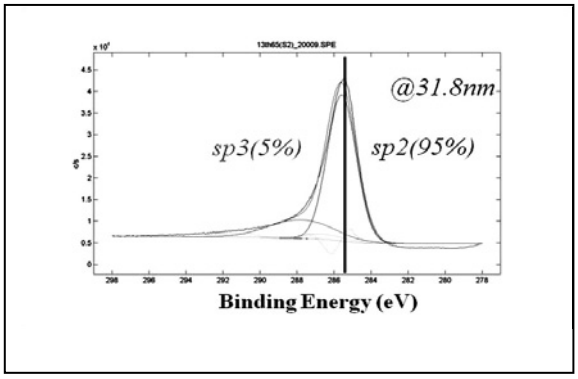

Fig.3.XPS fitting analysis of carbon at the depth of 31.8nm on sample S2.