§10. Simultaneous Spectroscopic Measurements of Wide Wavelength Range for W Ions in LHD Plasmas

Murakami, I., Suzuki, C., Morita, S., Goto, M., Oishi, T., Kato, D., Sakaue, H.A., Tamura, N., Sudo, S.

Tungsten is planned to be used as plasma-facing material of divertor plates in the ITER and spectral data of W ions are needed for spectroscopic diagnostics to examine impurity transfer and amount of W concentration in fusion plasmas. Many experimental and theoretical studies have been carried out to identify W spectral lines and to understand characteristics of W spectra, such as unresolved transition arrays (UTAs) at wavelength region 4 – 7nm seen for plasmas with electron temperature around 1keV[1,2]. LHD plasma with tungsten pellet injection has electron temperature less than 3keV and the W study in LHD is useful to examine W behavior in peripheral region for ITER.

In the 17th cycle experimental campaign, we measured W spectra with wide wavelength regions from extreme ultraviolet (EUV) to visible region simultaneously in order to understand characteristics of the spectral feature in plasmas with various electron temperatures. Tungsten was injected to LHD plasma as an impurity pellet or as a tracer in a TESPEL. These spectra in various wavelengths region can help to understand W ionic state distributions.

Figs. 1 and 2 show spectra for discharge #118759 at wavelength regions of 2 - 8 nm and 9 – 14 nm, respectively. We can identify spectral peaks at 2 – 3.5 nm as W^{23+} to W^{29+} ions by comparison with our previous work[3,4]. These peaks are very helpful to identify the charge distribution in plasma. Spectra shown in Fig. 2 are the first observation for this wavelength region 9 - 12 nm. CoBIT measurements predicted isolated spectral lines of W^{26+} ion at around 10nm and we observed similar spectra in LHD. Fig. 3 shows calculated spectra using collisional-radiative models for W^{22+} - W^{28+} ions and it also shows several lines of $4f^2$ - 4f5s transition from W^{26+} ion. These peaks well reproduce spectra observed in LHD. Such isolated lines are good candidates for 2D spectroscopic measurements.

Fig. 3 also shows UTA structures of W^{22+} - W^{25+} ions at 13 – 14 nm, which may produce a quasi-continuum in spectrum.

1) Pütterich, T. et al., Plasma Phys. Control. Fusion **50**, 085016 (2008).

2) Bar-Shalon, A. et al., J. Quant. Spect. Rad. Transf. **71**, 179 (2001).

3) Sakaue, H. A. et al., AIP Conf. Proc. **1438**, 91 (2012).

4) Morita, S. et al., AIP Conf. Proc. **1545**, 143 (2013).

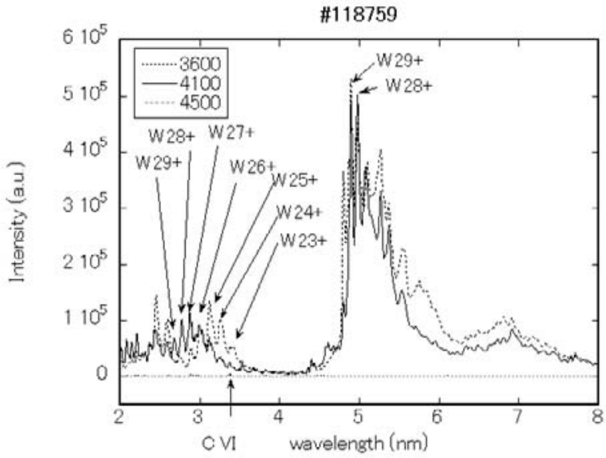

Fig.1 EUV spectrum at wavelength region of 2 - 8 nm taken by an EUV spectrometer for #118759 after a TESPEL injection. Spectral peaks of n = 5 - 4 transitions from W^{23+} - W^{29+} ions are identified.

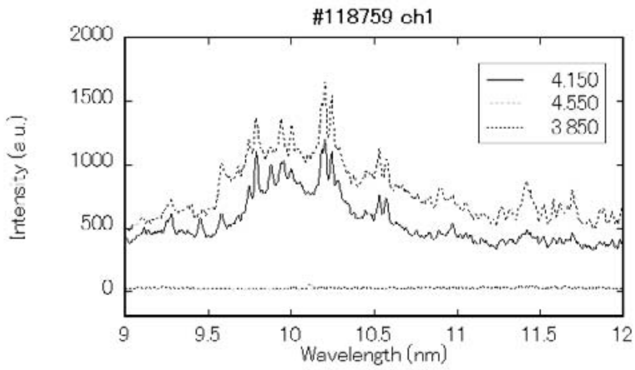

Fig.2 EUV spectrum at wavelength region of 9 – 12 nm taken by SOXMOS for #118759 at t = 4.15 and 4.55 s. Several isolated peaks are observed at around 10nm, which are predicted by CoBIT measurement.

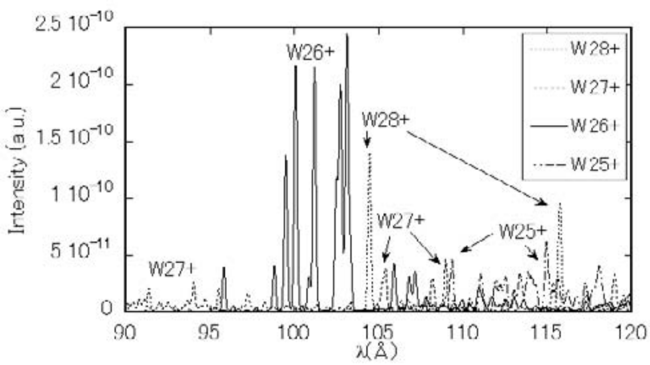

Fig. 3 Calculated EUV spectra for the same wavelength region as Fig.2 for W^{25+} to W^{28+} ions using the collisional-radiative models with assumption of electron temperature 700eV and electron density $5x10^{13}cm^{-3}$. Isolated lines are produced for W^{26+} ion, which correspond to the peaks seen Fig. 2 at around 10nm.