§4. 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 concentration of W ions in fusion plasma. Many experimental and theoretical studies on W ion spectra have been carried out by many groups to compile spectral data, to identify spectral lines, and to explain unresolved transition arrays (UTAs) which are quasi continuum spectra. Yet W spectra are not fully understood, especially for plasmas with electron temperature around and less than ~1keV, since extreme ultraviolet (EUV) spectra at wavelength region 4nm – 7nm shows UTA feature[1,2], for example. If electron temperature is higher than 3keV, W ions are highly ionized and spectral feature becomes simpler with discrete lines in EUV region.

In the 16th cycle experimental campaign, we measured W spectra with wide wavelength regions from EUV to visible region simultaneously in order to understand characteristics of the spectral feature in plasmas with various electron temperatures. W was injected as an impurity pellet or as a tracer in the TESPEL to plasma. These spectra in various wavelengths region can help to understand W ionic state distributions.

In Figs. 1 -3 show spectra for plasma #112877 at t=4.35s when central electron temperature T_e was about 3keV. For this plasma, a TESPEL with tungsten was injected at t=3.8s and central electron temperature was kept around 3keV until 4.3s, and decreased to 1.5keV because the NBI input pattern was changed and tungsten ions reached in the central region emitted radiation to lose electron temperature. Tungsten was ionized to be N-shell ions at T_e ~3keV and spectral lines of W^{42+} ~ W^{45+} ions are found at λ ~ 2.nm and λ ~ 6nm in Fig. 2. Fig.1 shows quasi-continuum spectrum at λ ~ 0 – 4.5 nm and it is hard to find discrete lines in this region. Fig. 3 shows some discrete spectral lines at λ ~ 16 – 21 nm, and line identification is undergoing.

We have been constructing collisional-radiative (CR) models of W ions. A CR model solves rate equations of excited states of each ion in steady-state including electron collision processes between excited states. We use the HULLAC code[2] to calculate atomic data for the CR model. Here recombination processes are not included in the CR model for spectral synthesis, since recombination processes are less important for most of plasma conditions in LHD. We try to synthesize spectra to compare with the experiments and to identify spectral lines. Identification of spectral lines in Fig. 2 was carried out by comparing with the synthesized spectra. Quasi-continuum seen in Fig. 1 and some lines in Fig. 3 are still hard to be reproduced with our current model. Our current model is still needed to be improved to obtain more realistic synthesized spectra. We will try to examine spectra taken at different time with different electron temperature.

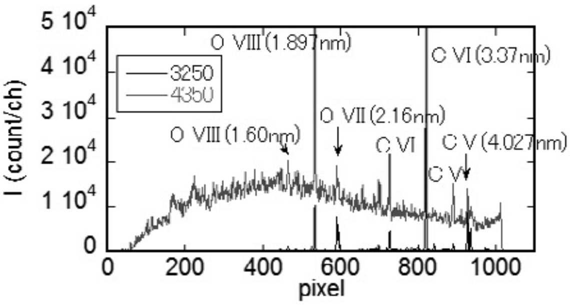

Fig.1 EUV spectrum at wavelength region ~ 0 - 4.5 nm taken by an EUV spectrometer for #112877 at t=4.35s and t=3.25s before a TESPEL injection. Continuum is increased maybe due to radiation from tungsten ions.

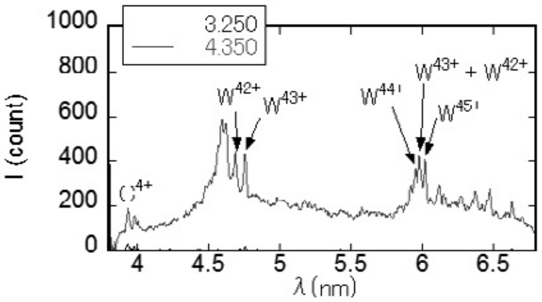

Fig.2 EUV spectrum at wavelength region ~ 4 – 6.8nm taken by SOXMOS for #112877 at t=4.35s. Discrete lines of W^{42+} ~ W^{45+} ions are identified.

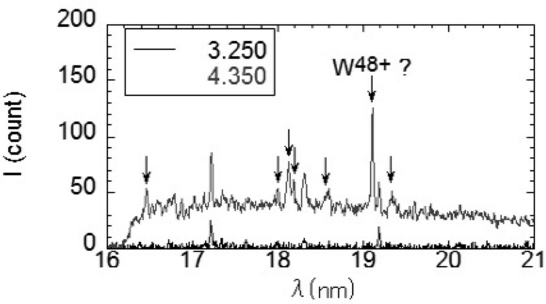

Fig. 3 EUV spectrum at wavelength region ~ 16 – 21nm taken by SOXMOS for #112877 at t=4.35s. Several tungsten lines are found.

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).