§13. EUV Spectroscopy of Highly Charged Tungsten Ions by Compact Electron Beam Ion Traps

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Tungsten is a strong candidate for the material of the plasma-facing components, such as the first wall and divertor plates, in ITER because it has excellent physical properties, such as a low sputtering yield, a high melting point, a low tritium inventory, and so on. However, since high particle and heat fluxes would cause serious damages to such components, tungsten is considered to be one of the most abundant impurities in the ITER plasma. Emission lines of highly charged tungsten ions thus play an important role in the spectroscopic diagnostics of the ITER plasma, and consequently the spectroscopic data of tungsten ions are strongly needed. To date, the spectroscopic studies of highly charged tungsten ions have been carried out by using high temperature (several keV) plasmas [1), 2)] and electron beam ion traps (EBITs) [1), 3), 4)] with relatively high electron energies (several to several tens keV). However, there is not yet enough data. In particular, the spectral data of moderate charge state tungsten ions (W^{10-30+}) are quite limited. To produce such moderate charge state ions, an EBIT should be operated with an electron energy of several hundreds of eV. Although several EBITs have often been operated with such a low energy electron beam, it has more or less difficulties because they have not been designed for such operation.

For the spectroscopic studies of such moderate charge state ions, we have developed a new compact EBIT [5), 6)]. The electron energy range of the present EBIT is 100 - 2500 eV and electron current is 30 mA, which is suitable for this purpose. Those parameters, which are rather low compared to those of ordinary EBITs, enabled us to downsize the device. The CoBIT has six ports currently used for an EUV spectrometer, a visible spectrometer, gas injector and pinhole camera. Tungsten was injected from gas injector, as a vapor of tungsten carbonyl ($W(CO)_6$). The various charge state ions in the trap of the CoBIT can be selectively produced with narrow charge state distribution by adjusting the electron beam energy and tungsten atom vapor density. The EUV spectrometer is of a slit-less type especially designed for the present CoBIT. The two kinds of a laminar-type replica diffraction gratings are used to focus the radiation on the surface of a back illuminated CCD, and the measurement wavelength ranges are 1-6 nm and 5-20 nm, respectively.

Figure. 1 shows the EUV spectra of highly charged tungsten ions obtained for the energy range of 800-1370 eV. In each spectrum, the beam energy and the highest charge state at that energy are shown. There are many previously-unreported lines of highly charged tungsten ions in this wavelength range. The charge state distribution at each energy is considered to be dominated by two or three main charge states. Detailed identification is ongoing through the comparison with theoretical calculations.

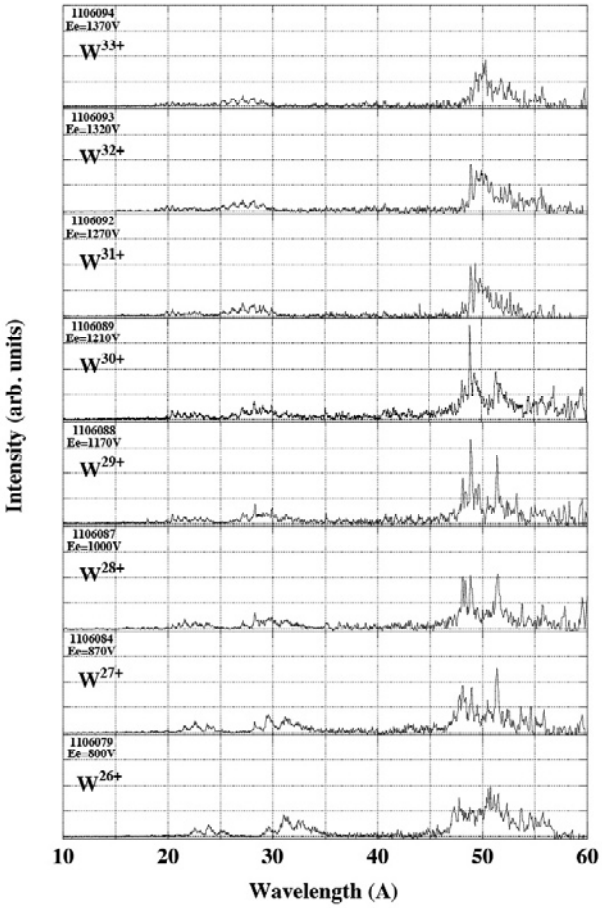

Fig. 1. EUV spectra of highly charged tungsten ions.

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