§35. High Resolution EUV Spectrometer for the Spectroscopy of Highly Charged Tungsten Ions in CoBIT

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Tungsten will be used for the material of divertor plates in ITER because of higher threshold energies for sputtering by light ion bombardment, the highest melting point in the chemical elements, and less tritium retention than that in carbon based materials. However impurity tungsten enters the high-temperature plasma and is ionized to highly charged ions, and then highly charged ions emit very strong photons of EUV and/or X-ray. This emitted photon has very important information on plasma diagnostics; information on electron and ion temperature, electron density, impurity ion abundance and impurity transportation. Nevertheless, it is the present conditions that those emission spectra are very complicated and those spectral data are very poor. Therefor, we observed spectra of highly charged tungsten ions in the extreme ultra-violet (EUV) by using electron beam ion traps.[1)]

An electron beam ion trap is a useful device for the systematic spectroscopic studies of highly charged tungsten ions. We have constructed a compact electron beam ion trap, called CoBIT[2),3)], and the extreme ultra-violet (EUV), the vacuum ultra-violet (VUV) and visible spectrometers were installed in CoBIT. We observed EUV spectra of highly charged tungsten ions and unreported lines were presented. Then, these lines were identified by comparing the wavelengths with our theoretical calculations. Previously we observed an unidentified emission lines which are expected from theoretical calculations from W^{26+} around 100Å in CoBIT. From the electron energy dependence of tungsten spectra, the observation lines were identified as 4f5s → $4f^2$ transition of W^{26+}. However, these observation lines could not be resolved to each angular momentum transitions because our spectrometer resolution was not enough. We designed the new spectroscope to overcome this problem. In Fig.1, we show the schematic illustration of CoBIT and spectrometers installed. The visible, VUV and two kinds of EUV spectrometers were installed in CoBIT.

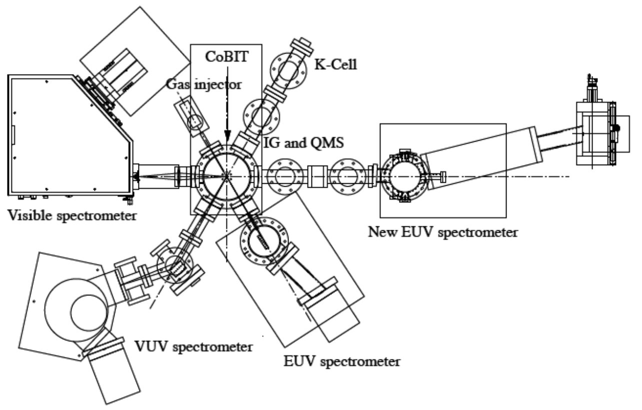

Fig. 1. A schematic illustration of CoBIT and spectrometers.

The characteristics of the spectrometers are listed in TABLE 1. This time, the new spectrometer which we designed is EUV II. The focal distance of new EUV II is long more than twice the focal distance of EUV I. Therefore it is possible to observe a high-resolution spectrum by using this EUV II spectrometer in comparison with EUV I spectrometer.

1) Sakaue, H. A. *et al*.:*Phy.Rev.A***92**, (2015) 012504
2) Nakamura, N. *et al*.: *Rev. Sci. Inst*rum. **79** (2008) 063104
3) Sakaue, H. A. *et al*.: *J. App. Phys.* **109** (2011) 073304

	EUV I		EUV II (New EUV)		VUV	Visible
Spectrometer (Grating)	30-002 (Shimadzu)	30-001 (Shimadzu)	001-0660 (Hitachi)	011-0659 (Hitachi)	Model 234/302 (McPHERSON)	MK-300 (BUNKOUKEIKI)
Groove number (l/mm)	1200	2400	1200	2400	2400, 1200	1800, 1200, 300
Incident angle (degree)	87	88.65	87	89	64 degrees	-
Focal distance (mm)	235	235	563.2	563.2	200	300
Useful wavelength range (nm)	5-20	1-6	5-25	1-6	30-550	200-1000
CCD detector	PIXIS-XO:400B		PyLON-XO-2KB		PIXIS-XO:400B	PyLON:2K

TABLE 1 The characteristics of the spectrometer installed in CoBIT are listed.