§13. Spectroscopy of Highly Charged Tungsten Ions Using Electron Beam Ion Traps

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Tungsten is a major candidate for the divertor material of ITER, so that its spectroscopic data over wide range of charge state are strongly needed to diagnose and control the high temperature plasma in ITER. An electron beam ion trap (EBIT) is a powerful device for accumulating such atomic data. At The Univerisy of Electro-Communications, we have two EBITs; one of them is a high-energy EBIT, called the Tokyo-EBIT [1], and another is a low-energy EBIT, called CoBIT [2]. The complementary use of these two EBITs allows us to study ions over a wide range of charge state. In particular, we are currently interested in the visible region because a lot of effort has already been paid for the shorter wavelength range such as VUV and X-rays at the Berlin EBIT [3, 4].

Figure 1 shows the typical setup for visible spectroscopy [5], which is used both for the Tokyo-EBIT and for CoBIT although the focal length and the size of the lens are changed depending on the ion source used. A Czerny Turner type of spectrometer (Jobin Yvon HR320) with a liquid nitrogen cooled CCD is used. Tungsten is injected into the EBIT as a vapor of $W(CO)_6$ through a gas injection system. To distinguish the lines of tungsten from those of carbon and oxygen, spectra are also observed while injecting CO and O_2 and compared with the spectra obtained with $W(CO)_6$ injection.

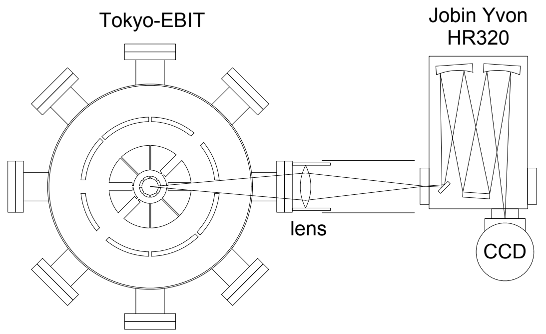

Fig. 1: Experimental setup for visible spectroscopy of highly charged tungsten ions.

Figure 2 shows a typical example for the elctron energy dependence of tungsten spectra obtained with CoBIT. Each spectrum in the figure was obtained with an exposure of 1 hr with an electron current of 10 mA. From the energy dependence, the charge state of the ion responsible for each line can be identified. Detailed identification is ongoing through the comparison with theoretical calculations.

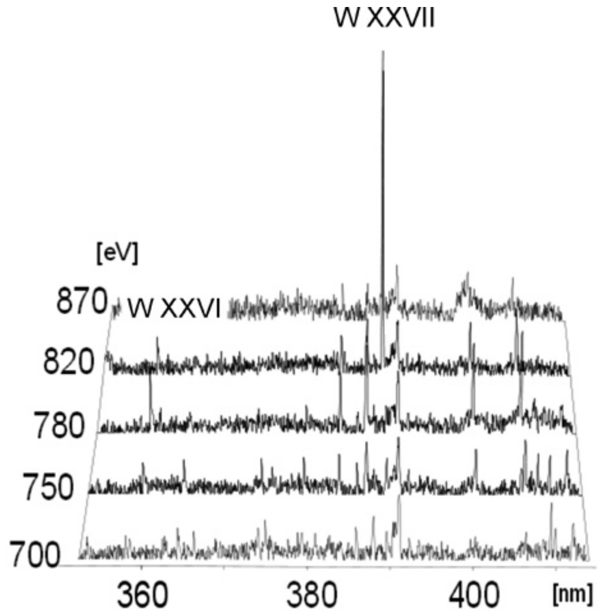

Fig. 2: Electron energy dependence of tungsten spectra obtained with the compact EBIT. The charge states preliminary identified from the energy dependence are shown.

To extend the wavelength range, we have developed a new grazing incidence spectrometer for the EUV region. It consists of a flat-filed grating with 2400 gr/m and a back-illuminated CCD. The spectrometer has been attached to the Tokyo-EBIT and is currently being tested. The wavelength range available with this spectrometer is 1-6 nm, where important lines are predicted to be observed for charge states of around 40+.

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