§9. 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 University 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 and EUV region because a lot of effort has already been paid for the shorter wavelength range such as VUV and X-rays at other EBIT facilities.

Figure 1 shows typical spectra of highly charged tungsten ions observed with the spectrometer[3)] that constructed under the auspices of this collaboration research program in the last fiscal year. For these measurements, the Tokyo EBIT was used with electron beam energies of 2.6 and 3.2 keV. The data acquisition time was 15 min with a 2400 gr/mm grating. The lines observed at around 6.1 and 6.2 nm are the 4s - 4p transition in W XLV and XLVI, respectively. Nakano *et al.*[4)] proposed that the intensity ratio between these lines is useful for the diagnostics of the ion density ratio in the ITER plasma. It is thus required to measure the electron energy dependence of the line intensity ratio. The measurements are currently in progress and the results will be published elsewhere.

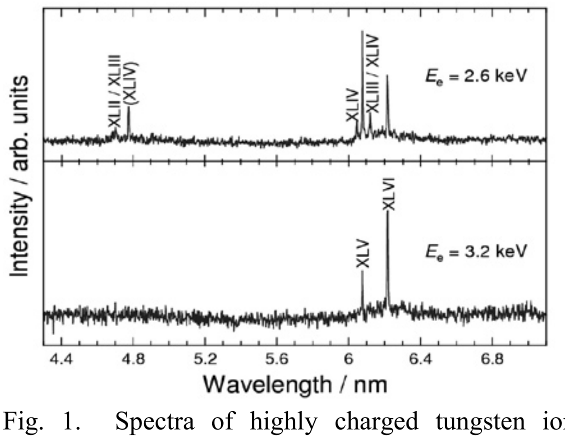

Fig. 1. Spectra of highly charged tungsten ions obtained at electron energies of 2.6 and 3.2 keV. The electron current was 40 mA for both the spectra.

Figure 2 shows typical visible spectra obtained with CoBIT at electron energies of around 800 eV. In this electron energy range, a relatively strong line was observed at 389 nm. The ion responsible for this line is assigned to W^{26+}, because it appeared when the electron energy exceeded the ionization energy of W^{25+}. Actually, the intensity ratio of this line with respect to the line at 387 nm, whose responsible ion was identified as W^{25+} in the present study, showed a sharp increase around the ionization energy of W^{25+} (784.4 eV). Although several other weak lines were observed in this wavelength range, their responsible ion is not W^{26+}, because they were also observed at lower electron energies. To identify the upper and lower levels of the observed lines, we made theoretical calculations of the energy levels, and concluded that the line is the M1 transition between the ground state fine structure levels of W^{26+} $(4f_{5/2}{}^2)_{J=4}$ - $(4f_{5/2}4f_{7/2})_{J=5}$.[5,6)]

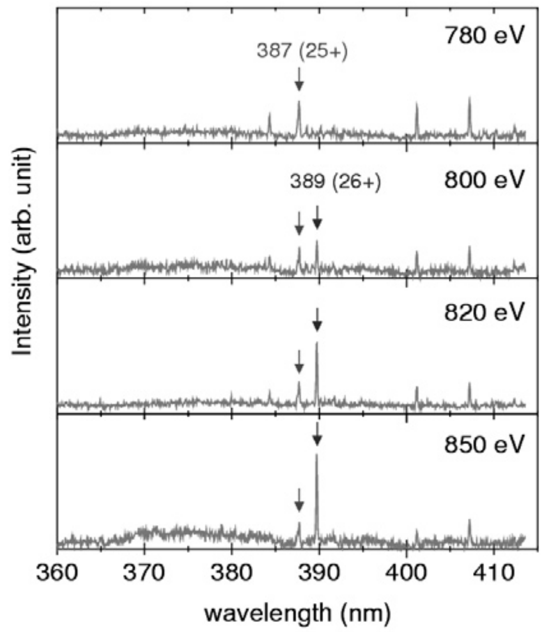

Fig. 2. Visible spectra of tungsten ions trapped in CoBIT with electron energies around 800 eV.

1) N. Nakamura et al.: Rev. Sci. Instrum. 69 (1998) 694.
2) N. Nakamura et al.: Rev. Sci. Instrum. 79 (2008) 063104.
3) Ohashi et al.: Rev. Sci. Instrum. (2011) in press
4) T. Nakano and The JT-60 Team, J. Nucl. Mater. (2010) in press.
5) A. Komatsu et al.: Phys. Scr. T144 (2011) 014012.
6) X. B. Ding et al.: J. Phys. B 44 (2011) 145004