§2. A Compact Electron Beam Ion Traps for Spectroscopic Studied of Highly Charged Tungsten Ions

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An electron beam ion trap (EBIT) was originally developed for studying few-electron heavy ions to test fundamental quantum theories, so that almost all EBITs in the world have been designed to be operated with rather high electron beam energy (~10 keV or more). On the other hand, spectroscopic data of moderate charge state ions which still keep many electrons are important for several areas. For example, atomic data of tungsten ions are very little for the charge states lower than about 30+ although they are strongly needed for successful operation of the next generation nuclear fusion plasma device ITER. 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 [1]. The electron energy range of the present EBIT is 100 - 2500 eV, which is suitable for this purpose. A schematic drawing of the present EBIT is shown in Fig. 1. The electron energy and current are 100-2500 eV and <30 mA, respectively. Those parameters, which are rather low compared to those of ordinary EBITs, enabled us to downsize the device. We adopted a high critical temperature super-conducting coil for the compression of the electron beam to reduce the running cost. The electron gun, drift tubes (DT), electron collector and extractor are fixed in the liquid nitrogen tank with the ceramic insulator Shapal M-soft. Because this insulator has a high thermal conductivity (90 W/m K), the electron collector can be cooled only by the thermal conduction from the liquid nitrogen tank without any water-cooling channels. This also helped to downsizing the device.

Fig. 2 shows the visible spectra of highly charged tungsten ions obtained for the energy range of 360-820 eV. Tungsten was injected from the gas injector as a vapor of $W(CO)_6$. In each spectrum, the beam energy and the highest charge state at that energy are shown. Lines indicated by the arrows in the figure are considered to be previously-unreported lines of tungsten. The charge state distribution at each energy is considered to be dominated by one or two main charge states. Detailed identification is ongoing through the comparison with theoretical calculations.

We have developed a compact EBIT for the spectroscopy of moderate charge state ions. The performance of the EBIT was tested by observing visible spectra of tungsten. The results showed that the new device is a powerful tool for the identification of previously-unreported lines because various charge state ions can be selectively produced with a narrow charge state distribution by adjusting the electron beam energy.

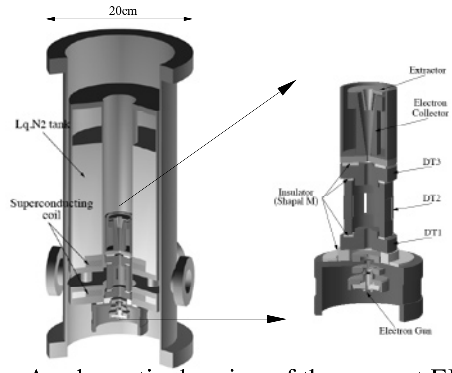

Figure 1. A schematic drawing of the present EBIT .

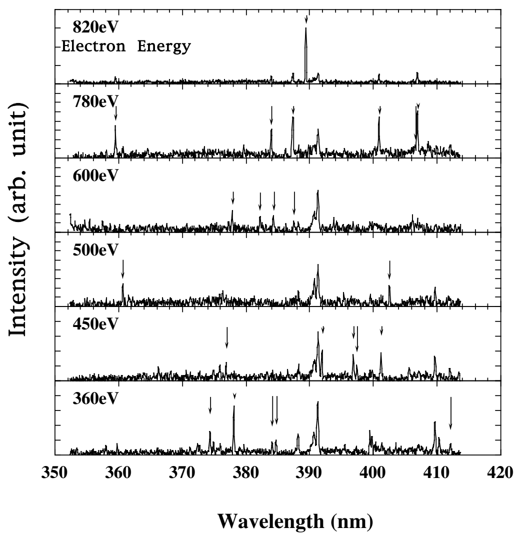

Figure 2. Visible spectra of highly charged tungsten ions.

[1] N. Nakamura et al., 2008 Rev. Sci. Instrum. 79, 063104.