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Advanced X-ray imaging crystal spectrometer using a segmented position sensitive detector for tokamak plasmas

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1. INTRODUCTION

An advanced X-ray imaging crystal spectrometer (XICS) has been developed that uses a two dimensional (2D) segmented position sensitive, multi-wire proportional counter [1-3]. The XICS provides spatially and temporally resolved spectra of the resonance lines of highly charged ions and the associated satellites from multiple lines for measurements of the profiles of the ion and electron temperatures, toroidal rotation velocity, impurity charge-state distributions, and ionization equilibrium. The 2D segmented detector has been upgraded for increasing the photon count rate capability and spatial resolution. Recently, a vacuum brazing technique for bonding a thin beryllium window onto the 2D detector chamber made of Al has been developed in order to improve the detector performance as compared to the typical epoxy-bonding method. The current development status of the advanced X-ray imaging crystal spectrometer, the vacuum brazing technique, and the initial performance test results of the segmented 2D detector are presented.

2. SPECTROMETER DEVELOPMENTS

The advanced X-ray imaging crystal spectrometer (XICS) consists of a single spherically bent crystal, a two dimensional (2D) segmented position sensitive multi-wire proportional counter and an X-ray tube for easy calibration. Figure 1 (a) and (b) show the design view and fabricated spectrometer of the XICS, respectively.

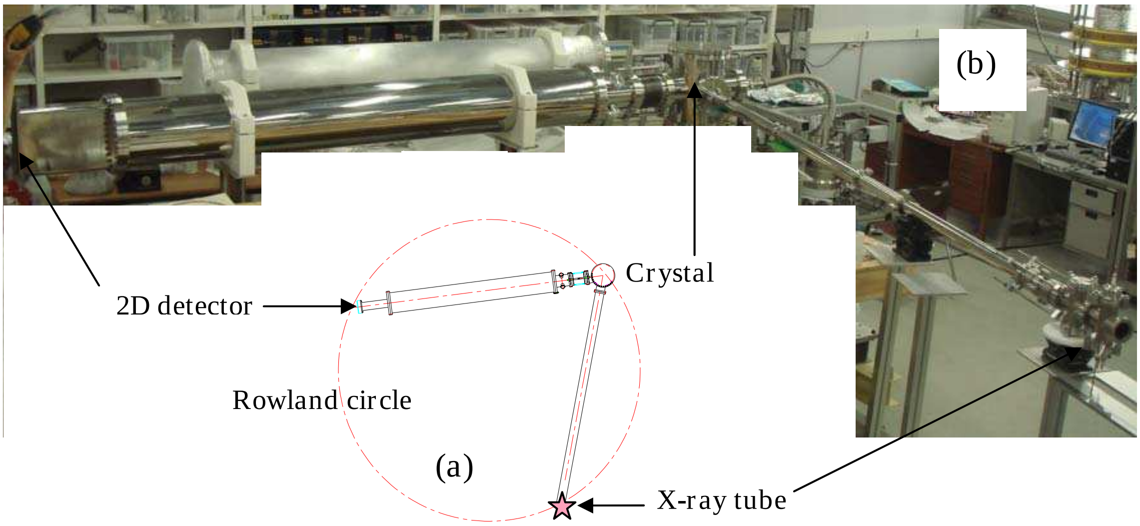

Fig. 1. A design view (a) and fabricated XICS (b).

Figure 2 (a) and (b) show a vacuum brazing furnace and vacuum test of the sample piece of Be window after brazing, respectively. The Be window on the 2D detector was attached a typical epoxy-bonding method so far. However, the epoxy may react with the quenching gas inside of the detector and this effect degrades the detector performances. The vacuum brazing method between the Be window and Al chamber was developed in order to improve the detector performance. The sample of the Be window was successfully brazed in the Al body and this technique will be applied to the 2D detector.

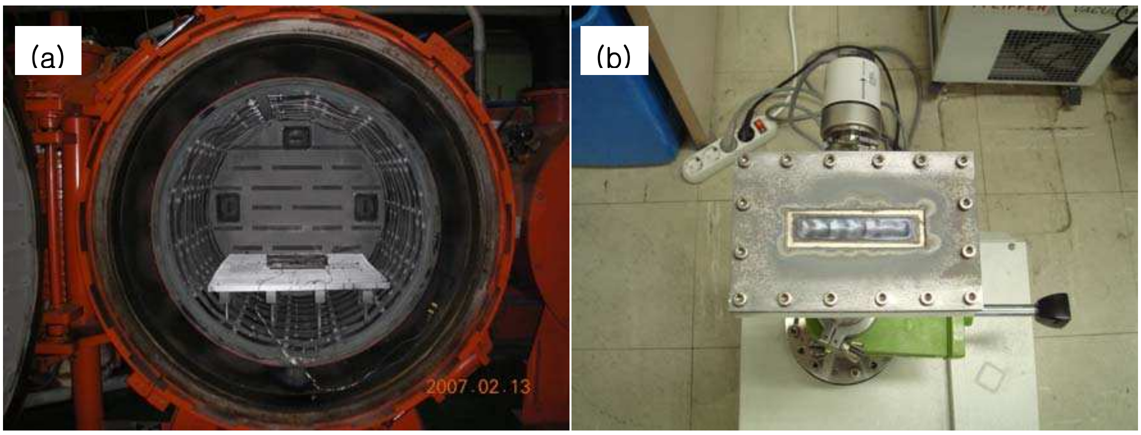

Fig. 2. A vacuum brazing furnace (a) and sample piece of Be window (b).

Figure 3 shows fabrication procedures for the 2D segmented position sensitive multi-wire proportional counter. The Be window was attached by the epoxy-bonding at this time. The 10 μm diameter gold plated tungsten wires were used for the anode printed circuit board (PCB) frame and two equally divided copper strips were utilized for the cathode PCB.

Fig. 3. Fabrication procedures for the 2D detector.

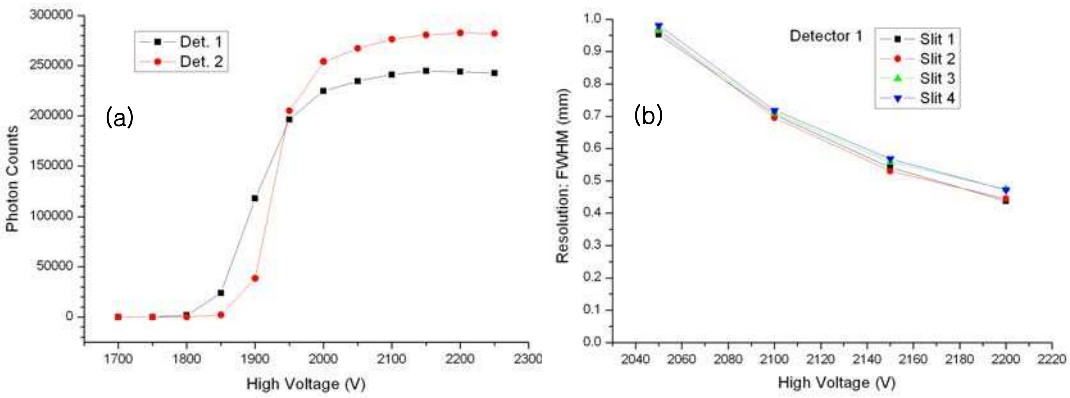

Fig. 4. Performance test results for the 2D detector:

(a) counting plateau, (b) spatial resolution.

Figures 4 (a) and (b) show the photon counting plateau and spatial resolution of the fabricated 2D detector, respectively. The plateau starts at the applied high voltage of 2200 V which is much less than that of the previous result [3]. The lower plateau high voltage is due to the fact that the distance between the anode and cathode PCBs was reduced, and this effect makes the detector more stable and safe. The measured full width at half maximums (FWHMs) for the detector 1 approaches to 0.4 mm when the applied high voltage is increased to 2200 V, and this result is very similar to the detector 2. The spatial resolution of the detector (or FWHM) will be improved continuously since the ion temperature resolution is related with the spatial resolution of the detector.

4. SUMMARY

The advanced X-ray imaging crystal spectrometer utilizing a 2D segmented position sensitive has been developed. The 2D detector has been upgraded for increasing the photon count rate capability and spatial resolution. The developed vacuum brazing technique will be appled to the next version of the 2D detector fabrication.

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