§17. Development of Energy Resolved X-ray Video Camera

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To study impurity behavior in magnetically confined plasma by injecting tracer-encapsulated solid pellet (TESPEL), new kind of X-ray detection system is required. The detector must measures the radial profiles of time-resolved soft X-ray spectra emitted from high temperature plasmas in LHD. The plasmas emit strong soft x-ray spectra in an energy range from 1.0 keV to 10 keV. The spectra consist of continuum as bremsstrahlung emitted from electrons and K_α lines emitted from the impurities such as ionized argons, and transition metals.

We have started, from this fiscal year (FY2012), development of energy resolved X-ray video camera by using Silicon-On-Insulator pixel detector (SOIPIX). Structure of the SOIPIX is shown in Fig. 1. The SOIPIX has both thick high-resistive radiation sensor and CMOS readout circuit in a single chip [1].

To get good energy resolution, the SOIPIX detector must be cooled to around -50 ºC, so it is mounted within a vacuum chamber (Fig. 2). A pulse tube refrigerator is provided as a cooling system. The cooling by the refrigerator is easy to use and there is almost no need to maintenance. However, since we have little experience of the refrigerator and there was some care for magnetic influence used near the LHD, we also prepared liquid nitrogen Dewar vessel to the vacuum chamber. We confirmed the detector was cooled below -50 ºC in few hour with both cooling system.

Although we started to use existing SOIPIX detector, we are also developing a new detector optimized for this measurement. Photograph of the first prototype chip (named LHDPIX) is shown in Fig. 3. The LHDPIX1 has 264 x 72 pixels of 18 um square, and data can be readout without dead time by using a rolling-shutter mode.

After testing all the components and getting permission to install our system near to the LHD, we are scheduling a first test in the next LHD cycle.

1) "Development of SOI Pixel Process Technology", Y. Arai, et al., Nucl. Instr. and Meth A. Vol. 636, Issue 1, Supplement, pp. S31-S36. doi:10.1016/j.nima.2010.04.081.

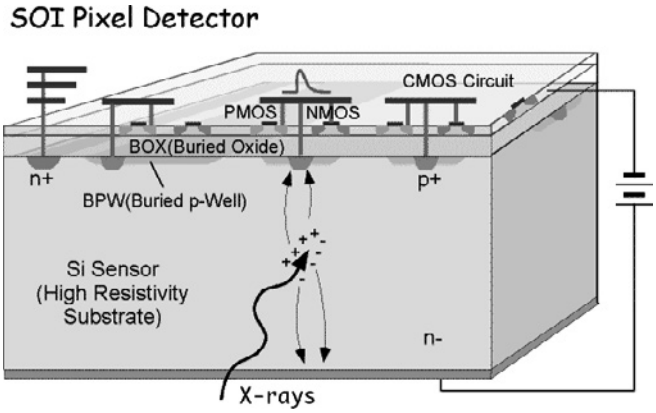

Fig. 1. Structure of the SOI pixel detector.

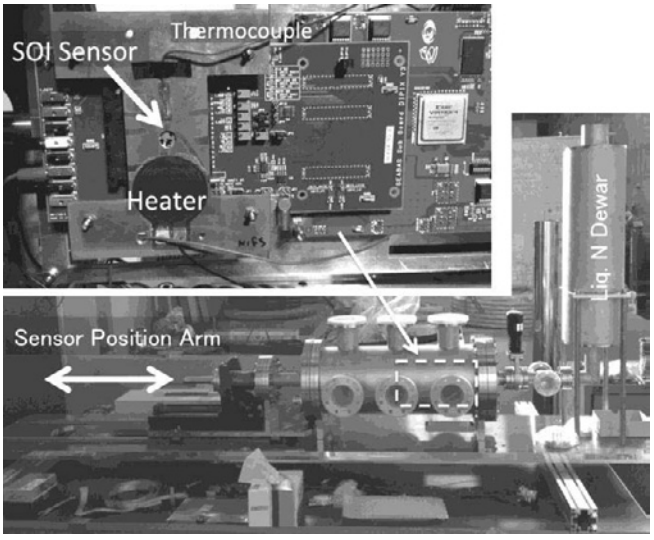

Fig. 2. Photograph of the vacuum chamber (bottom) and the SOI sensor board (upper), which is mounted in the chamber. The position of the sensor can be adjusted from outside rod arm. Thin Be foil is used for the X-ray entrance window.

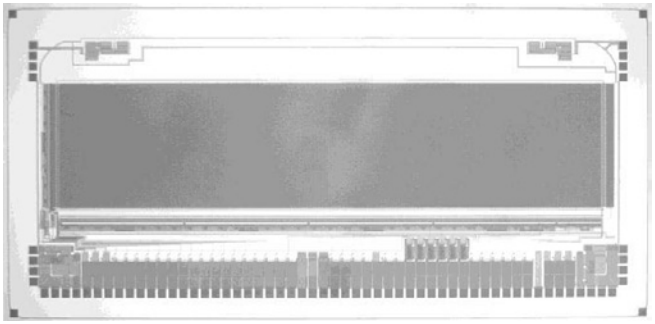

Fig. 3. Photograph of the LHDPIX1 chip. Size of the chip is 2.9 mm x 6mm. Pixel size is 18um square and number of pixels is 264 x 72.