§9. Calibration of a Soft X-ray Detector Array for the Measurement on LHD

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The measurement of the internal MHD activity using X-ray emissions has become a standard method. In order to obtain good spatial resolution, a great many detectors are used. Especially for tomographic methods, data from many viewing cords are needed to reconstruct reliable iso-emissivity surfaces, which are assumed to represent surfaces of constant poloidal flux. Calibration of the sensitivity should be very important.

Linear array of high-speed PIN photodiode without a glass cover is a possible candidate for the detector. Photons of X-rays are detected directly in the detector through an ionization process. Since detectors are formed on a common silicon wafer, the sensitivities of them are expected to be the same; the difficulty of the calibration is greatly reduced. Besides this advantage, combined type detector, whose physical size is small, can be fit to anywhere in the LHD.

We tested a PIN photodiode array which was originally developed by Kyoto University for WT-3 Tokamak and Hamamatsu Photonics K. K. The array contains 20 detectors, each 12 mm $\times$ 1.5mm, with a center-to-center spacing of 2.54mm. The entire chip is about 50mm long. We make use of synchrotron radiation lights from the Photon Factory (PF) storage ring of the National Laboratory for High Energy Physics(Tsukuba). A Beam line(BL11A) which is prepared for soft X-ray measurement(250eV-1200eV) is used.

The light from the storage ring is introduced into a grating monochromator of BL11A. The monochromatized light is then collimated ($\phi \sim$ .5mm) onto the surface of each detector. The intensity of the light itself is monitored by an Au detector using photoelectric effects. The output current of the detector is measured by a pico ampere meter and compared to that of the reference detector(AXUV-100 manufactured by IRD) whose response was measured previously. Typical spectral responses of the detectors are shown in Fig. 1. The sensitivity has no characteristic peaks and dips in this range. It is shown that the difference among detectors is very small. The dispersion of the sensitivity is less than 5% in this spectral range.

The crosstalk for visible light on the specification sheet is negligibly small ($< 1\%$). However, the photons are detected in the depression layer that is larger than P-layer which detect visible light[1]. We measured the signal from adjacent detector to make sure that the crosstalk ratio is small for the measurement. The measured value is 7 % (integrated over the photon energy). Though it is small enough, actual crosstalk ratio is less than this value. The light is somewhat scattered at the collimator. The crosstalk, however, seems to increase with the energy of the photons. We should measure the ratio with higher energy(1 $\sim$30 keV). In that energy range, some of the photons pass through the detector; we can check the high energy limit of this detector.

In conclusion, we tested the PIN photodiode array using the soft X-ray from PF. The variation of the sensitivity is very small; it is suitable for the detector of soft X-ray measuring system of LHD. We will introduce this detector to the CHS device and test the performance.

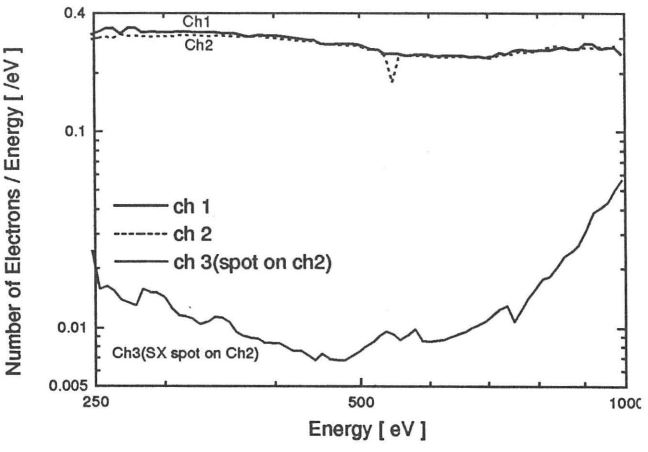

Fig.1: Photo sensitivity as a function of the energy of the photon. The measured signal at the adjacent detector(ch.3) is also shown.

Reference

[1] Silicon Photodiodes and Charge Sensitive Amplifies for Scintillation Counting and High Energy Physics, Internal Report, Hamamatsu photonics