The SPring-8 Detector Projects

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1. Introduction

One of the most straightforward ways to classify the x-ray imaging detectors is to categorize them into either the time-integrating type or the time-differentiating type. Imaging plates represent the time-integrating type, while multi-wire proportional chambers represent the time-differentiating type so far. As the third generation of synchrotron radiation facilities of APS, ESRF, and SPring-8 have started revolutionizing the experimental approaches in various fields of synchrotron radiation science, it is anticipated that the instruments for acquiring x-ray images in these fields will also take a new approach by introducing advanced technologies.

In this respect, the recent activities around CCD x-ray imaging sensors can be regarded as one of the successful approaches taking place in the time-integral type detectors, and so are those around the Micro-Strip Gaseous Chambers in the time-differentiating type detectors. Advanced protein crystallography and the time-resolved small angle x-ray scattering experiments to be carried out at SPring-8 offer opportunities to demonstrate their excellent capabilities to CCD x-ray imaging sensors and microstrip gaseous chambers, respectively. The projects related to these two detectors mentioned above have been designed to form the core of research at the SPring-8 detector group [1, 2]. Progress made in these projects during 1996 as well as the general features of these detectors are described in this report.

2. Multiple CCD X-ray Detector (MCCDX)}

Under the direction of the SR Structural Biology Research Group of RIKEN, this detector group has developed an array of CCD x-ray detectors, is called the *"Multiple Charge-Coupled-Device X-ray Detectors"* (hereafter referred to as MCCDX) (See Fig.). Construction of the MCCDX was completed at EEV in the UK, and transported to SPring-8 at the end of September 1996 as scheduled.

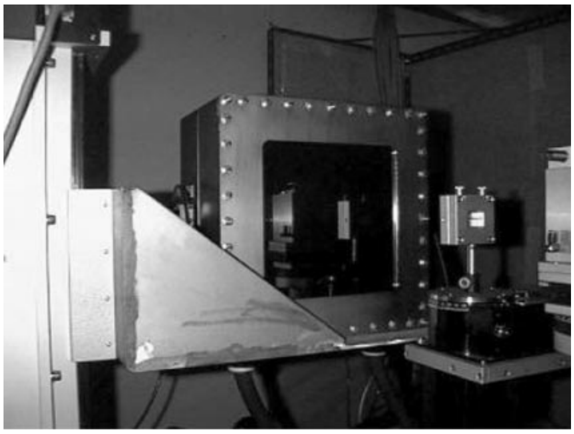

Fig.1: The Multiple Charge-Coupled-Device X-ray Detector constructed at EEV, UK.

The MCCDX is constructed in such a way that 16 modules of CCD x-ray detectors are integrated into a [4 × 4] rectangular matrix with an effective detection area of 200 mm × 200 mm as shown in Fig. 2. Each module of the CCD x-ray detectors is comprised of a scintillating screen, a fiber optic taper (hereafter referred to as FOT), and a large format scientific CCD. The large and small ends of the FOTs have the effective areas of 50 mm × 50 mm and 25 mm × 25 mm, respectively, with a surface reduction ratio of 25%. The scintillating screen made of $Gd_2O_2S:Eu$ is coated on the large ends of the fiber optic tapers combined. The CCDs attached to the FOTs are "large area CCD image sensors of a slow scan scientific version (EEV, CCD05-30)", which have the image area of 27.95 mm × 25.92 mm covered with 1242 × 1152 pixels. The CCDs are operated at 0C°, and are read out with a readout frequency of 1 MHz in the inversion mode. The data acquisition system linked to the MCCDX consists of 16 modules of the VME-based ADC units that are controlled by a DEC Alpha station. The ADC units convert the analog video signals from the MCCDX into digital signals with a dynamic range of 16 bits at a sampling rate of 1 MHz.

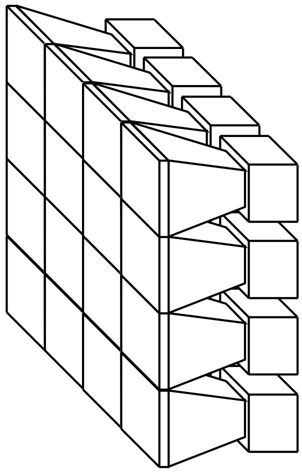

Fig.2: A Schematic of MCCDX.

Preliminary tests on the MCCDX are currently underway as reported elsewhere in this volume [3], through which the detector group has confirmed that the MCCDX is functioning well as expected. After completing the preliminary test, the group will start an intensive investigation on the MCCDX system to evaluate its performance in terms of the sensitivity, the position resolution, the effective dynamic range, and so forth.

3. MicroStrip Gaseous Chamber (MSGC)

In collaboration with Professor T. Tanimor's group at Tokyo Institute of Technology, the SPring-8 Detector Group has also been engaged in the 2-dimensional *Micro-Strip Gaseous Chamber* (MSGC) project to develop a next-generation of X-ray imaging detectors to be employed at SPring -8. The MSGC is a novel gaseous detector, surpassing conventional multi-wire proportional chambers, by realizing not only an excellent position resolution but also a capability for the very high counting rate of $10^7 Hz/mm^2$ based on the micro-strip electrodes with a few hundred um pitches [4, 5, 6].

Figure 3 shows a schematic of a prototype MSGC constructed with a 50 mm × 50 mm detection area [7, 9, 8, 10]. It has 254 anode- and 255 back-strips placed orthogonal to each other on a thin polyimide substrate, 20 um thick. An electric field is formed by a bias voltage of the anode and cathode strips, and a drift plane placed 3 mm above these strips. A gas mixture of argon and ethane fills the space between the drift planeand the strips. This new MSGC can produce a 2-dimensional X-ray image by detecting both anode- and back-strip signals, although most of the existing MSGCs could give only an 1-dimensional position for anode-strips. Each strip is printed at 200µm pitch attaining the position resolution around 60 µm (rms) with a digital readout method.

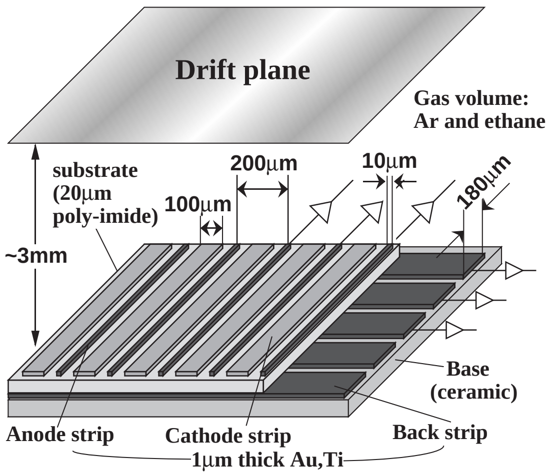

Fig.3: Schematic of the prototype detector with a 50 mm × 50 mm detection area.

A feasibility test with a synchrotron radiation source was performed at the 6C beamline of the KEK-PF facility in December 1996 [10]. Figure 4 shows a 2-dimensional image of a small angle X-ray scattering (SAXS) obtained for a collagen of a chickens tendon. The incident beam is the 9 keV monochronized X-rays with a spot of 1mm in diameter. Figure 5 shows the meridional reflection image obtained from Figure 4. The peaks of higher than the 12th order are clearly resolved in this image, and the left-right symmetry and the flatness are excellent.

The detector group is currently developing a full-scale MSGC with an extended detection area of 100 mm × 100 mm and a high speed readout system based on CPLD

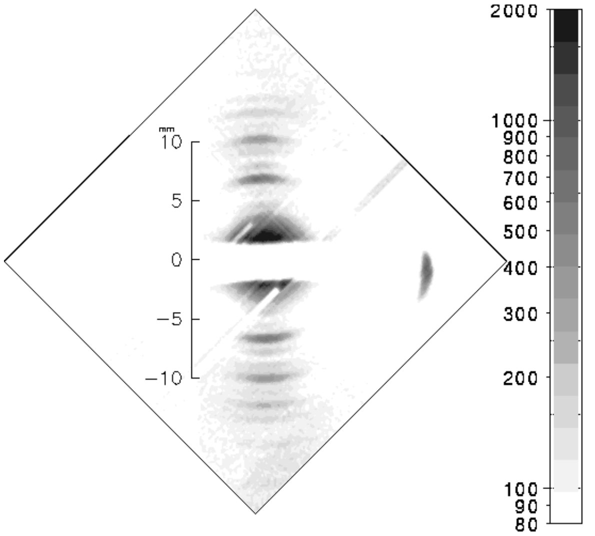

Fig.4: 2-dimensional image of SAXS experiment with a collagentarget at 9 keV X-ray beam.

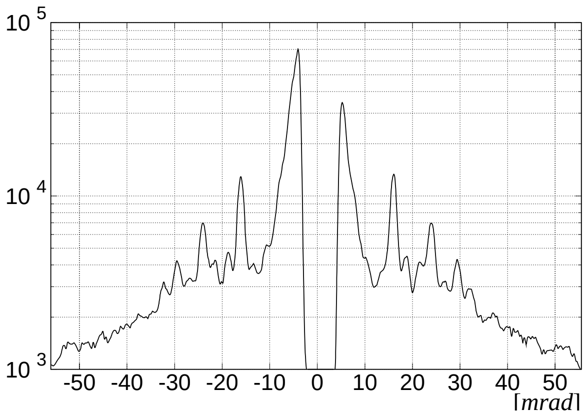

Fig.5: Angular distribution of SAXS experiment with a collagen target at 8 keV X-ray beam.

modules. This 100 mm × 100 mm MSGC will be used for SAXS experiments at the RIKEN beamline I for protein crystallography.

References

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