The SPring-8 Detector Projects

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1. Introduction

Having reviewed the x-ray detector projects that the SPring-8 project team had been conducting, the international advisory committee of SPring-8 recommended last year that the project team should pay more attention to CCD-based x-ray detectors as well as two-dimensional energy-resolving detectors [1]. The project team now considers that they succeeded in complying with this recommendation by initiating a new detector program called "Multiple CCD X-ray Detector Project", and by making a significant improvement in "Microstrip Gaseous Detector Project." Besides these two detector projects, there are four other detector projects continuing as a part of the project team activities, which are (1) the 1D CdTe detector project, (2) the imaging plate detector project, (3) the x-ray TV detector project, and (4) the proportional scintillation imaging chamber project. The following is the current status of each project, including the major progresses made last year.

2. Multiple CCD X-ray Detector

Under the direction of the SR Structural Biology Research Group of RIKEN, the SPring-8 project team completed a conceptual design on *the multiple CCD x-ray detector* May 1995, and started fabricating the first model in collaboration with EEV Co. Ltd. in UK from October 1995. The model will have a Gd_2O_2S scintillating screen with an effective detection area of 200 mm × 200 mm. The scintillating screen will be directly attached to a 4 × 4 matrix of fiber optics tapers with an image reduction ratio of 0.3. The smaller end of each fiber optics taper will be optically coupled to scientific CCD with a pixel size of 1000 × 1000. Operated near 0 °C, the model is expected to have a dynamic range higher than 13 bits. The x-ray images observed will be transferred to a workstation for further analysis. The model will be installed to the RIKEN beamline for protein crystallography.

3. MicroStrip Gaseous Detector

Because of its excellent time resolution as fast as 10 nsec, *microstrip gaseous detectors* have been regarded as a highly promising instruments in time-resolved diffractometry among the third generation synchrotron radiation facilities. During the course of developing the detector in this direction, however, Professor T. Tanimori and his collaborators had long realized that the electric field structure in the detectors should be well optimized in terms of the ion returning processes to attain a long-term gain stability. Having carried out an intensive computer simulation on the electric fields under varying the geometric parameters of the microstrip structures, they began fabricating an optimized pattern of microstrip structure onto integrated circuit chips since last year, by employing multi-chip module technology in collaboration with Toshiba Co. Ltd. in Japan [2]. The prototype chips fabricated were mounted on a ceramic package with 600 connected pins, having an effective detection area of 50 mm × 50 mm with a very thin substrate made of poly-imide, on which 250 anode strips and the equal numbers of backplane strips were orthogonal oriented to each other. The prototype chips were then placed in a vacuum-tight vessel filled with argon (90%) + methane (10%) gas mixture at 1 atm, and were submitted to various types of experimental verifications such as a long-term gain stability under the x-ray beam irradiation up to an intensity of 10^7 photons/mm^2/sec. By using the prototype, they have already started a real-time 2D x-ray imaging with a spatial resolution better than 100 μm, opening a new field of applications of this detector to x-ray polarization measurements. They are on way to fabricating full-scale models with an extending detection area of 100 mm × 100 mm, which will be used for small angle x-ray scattering experiments at the RIKEN beamline for protein crystallography [3].

4. 1D CdTe Detector

Due to its high detection efficiency to hard x-ray photons and of its cryogenic-free property, *the 1D CdTe detectors* have been considered as one of the most favorable devices for high energy Compton scattering experiments. In collaboration with Shimadzu Co. Ltd., Professor N.Sakai of Himeji Institute of Technology have fabricated a full-scale model with a sensitive area of 64 mm × 128 mm, having 512 independent channels. Each channel is composed of eight linearly arranged CdTe unit sensors (0.25 mm in width, 8 mm in length, and 0.8 mm in thickness), which is associated with its own electronics consisting of a preamplifier, a lower-level discriminator, and a counter. Although the full-scale model has shown a satisfactory performance in measuring Compton profiles of aluminum samples under irradiation of hard x-ray at PF/KEK [4], it is their intention to substitute pure CdTe sensors with CdZnTe sensors which have much better energy resolutions than the pure ones. They are currently focusing their best effort upon the Peltie cooling system to attain a superior stability in the operational temperature of the system, which will be indispensable for appreciating the excellent energy-resolving power of CdZnTe sensors.

5. Imaging Plate Detector

In collaboration with Rigaku Co. Ltd., Princeton Instruments Co. Ltd., and Kino-Meresgrio Co. Ltd., *the imaging plate detector* project, conducted by Dr. N. Kamiya of the SPring-8 project team, has successfully been approaching its goal by completing an advanced imaging plate detector system. Inducing the photostimulated luminescence by line-shaped laser light, this advanced system will read out the x-ray images stored in the plates with a CCD camera through an optical lens system of large numerical aperture with a readout cycle of 430 kHz. The system will be capable of reading out an extensive detection area of 400 mm × 500 mm within a minute. The data acquisition system for the advanced system is also currently being optimized in order to effectively transfer a vast amount of information read out from the imaging plates to a host computer. Since they have already attained the horizontal and vertical spatial resolutions of 112 μm and 171 μm, respectively, with the prototype previously constructed, the advanced system is expected to have the same level of spatial resolutions [5].

6. X-ray TV Detector

Having succeeded in fabricating a 9-inch Be-window x-ray image intensifier in collaboration with Hamamatsu Photonics Co. Ltd. during its R&D phase, *the x-ray TV detectors project* undertaken by professor Y. Amemiya of the University of Tokyo has been entering a new phase of applying the device to various types of actual SR experiments. Two-dimensional time-resolved diffraction patterns from, for example, frog skeletal muscle or polymer films during contraction under stretch have been observed with this instrument, having a dynamic ranges wider than 5 orders of magnitude and point spread functions with a FWHM less than 300 μm [6], under the suppression of the image distortion caused by an environmental magnetic field with an on-site image distortion monitoring system.

7. Proportional Scintillation X-ray Imaging Chamber

By the time of writing this report, *the proportional scintillation x-ray imaging chambers* project, directed by Dr. M.Suzuki of the SPring-8 project team, has been almost completed by constructing a complete model of a proportional scintillation x-ray imaging chamber, which consists of a parallel plate avalanche chamber and an image-intensifier-associated CCD camera. This instrument is highly space-charge resistive due to the low applied electric field employed, under which practically no electron multiplication could proceed. It has been confirmed that the instrument can successfully monitor the monochromatized direct beam without any instabilities for longer than a couple of hours, providing real-time 2D beam profile images. The device has also been applied for Laue diffractometry of several well known samples such as cholesterol powder, visualizing the diffraction patterns within a second with an appreciable quality [7].

References

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