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A tilted fiber-optic plate coupled CCD detector for high resolution neutron imaging

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1. Introduction

Neutron imaging has been used for fuel cell study, lithium ion battery study, and many scientific applications. High quality neutron imaging is demanded for more detailed studies of applications, and spatial resolution should be considered to get high quality neutron imaging. Therefore, there were many efforts to improve spatial resolution [1-4]. One of these efforts is that a tilted scintillator geometry and lens coupled CCD detector for neutron imaging system were used to improve spatial resolution in one dimension. The increased spatial resolution in one dimension was applied to fuel cell study [5]. However, a lens coupled CCD detector has lower sensitivity than a fiber-optic plate coupled CCD detector due to light loss. In this research, a tilted detector using fiber-optic plate coupled CCD detector was developed to improve resolution and sensitivity. In addition, a tilted detector can prevent an image sensor from direct radiation damage. A schematic of a tilted fiber-optic plate coupled CCD detector is shown in Fig 1.

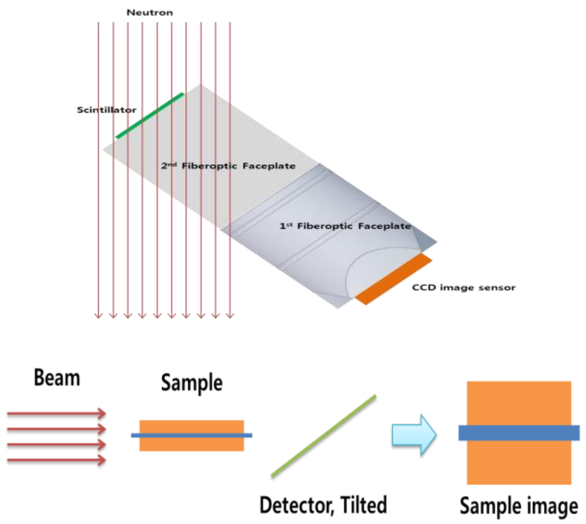

Fig. 1. A schematic of a tilted fiber-optic plate coupled CCD detector.

2. Methods and Results

2.1 A tilted fiber-optic plate coupled CCD detector

A tilted fiber-optic plate coupled CCD detector was installed using a $Gd_2O_2S(Tb)$ scintillator, high performance CCD camera, fiber-optic plate, and rotation stage. A $Gd_2O_2S(Tb)$ scintillator is widely used for neutron and x-ray imaging. Therefore, this detector can be used for both neutron and x-ray imaging. The specification of a high performance CCD camera (Model: PIXIS-XF) is shown in Table I. A fiber-optic plate that has enough length was combined with a scintillator and CCD camera as shown in Fig. 2.

Table I: The specification of high performance CCD camera (Model: PIXIS-XF)

CCD image sensor	e2v CCD42-40; front-illuminated, grade 1, AIMO
CCD format	2048 x 2048 imaging pixels 13.5 x 13.5 um pixels 100% fill factor 27.6 x 27.6 mm imaging area
Deepest cooling temperature	-35℃ guaranteed with room temperature water
Cooling method	Water cooling standard
Dark Current @ -35℃	0.05e-/p/sec (typical), 0.15e-/p/sec (max)
Non-linearity	<2% @ 100kHz

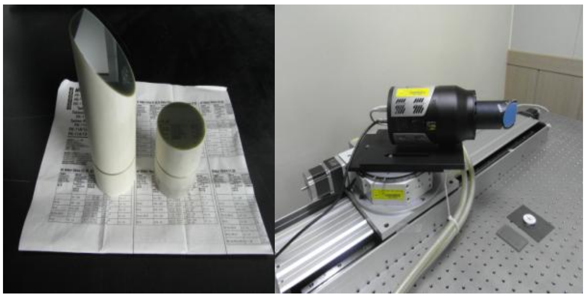

Fig. 2. Photographs of fiber-optic plates and a tilted fiber-optic plate coupled CCD detector.

2.2 Imaging performance

The imaging performance of a tilted detector was evaluated using x-ray source instead of thermal neutron source. The X-ray image of a 10um slit phantom was obtained using 35kVp 1mA X-ray source as shown in Fig. 3. A slit phantom test was conducted to determine spatial resolution of a tilted detector at tilting angle with 45 degree. We could obtained clear slit image and line profile of a slit image as shown Fig. 4.

Fig. 3. X-ray image of slit phantom

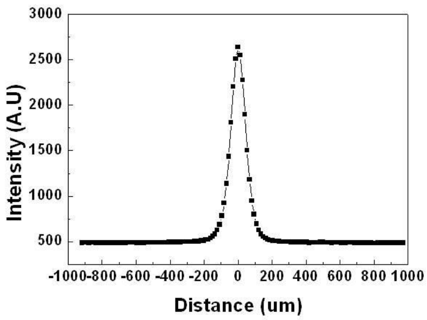

Fig. 4. Line profile of a slit phantom image

3. Conclusions

A tilted fiber-optic coupled CCD detector was developed for high resolution neutron imaging and tested using X-ray source. The tilted detector will be tested at thermal neutron irradiation facility and discussed about the sensitivity and spatial resolution when compared with a lens coupled CCD detector.

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