# Imaging Performance of Neutron Flat-Panel-Detector using IGZO-TFT

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## ABSTRACT

We present the imaging performance of a neutron flat-panel detector (nFPD) based on In-Ga-Zn-O (IGZO) thin-film transistor (TFT)/photodiode array coupled with a LiF/ZnS scintillator sheet. Coupling the scintillator directly to the sensor enables high spatial resolution and high sensitivity. Moreover, unlike lens-coupled neutron cameras, the new imaging detector has a large field of view and the size of the detector itself is thin and easy to handle. At the conference, we report on the neutron imaging results with an IGZO nFPD, its performance evaluation, and a demonstration of three-dimensional computed tomography with neutrons at compact neutron sources.

## 1 Introduction

Neutron imaging is a powerful tool for non-destructive testing. Recently, compact accelerator-driven neutron sources such as RANS at RIKEN and AISTANS at AIST, have been developed, making neutron imaging more accessible [1,2]. Accordingly, demands of neutron imaging is increasing especially for industrial use. However, there is room for improvement in neutron imaging detectors in terms of sensitivity, field of view, spatial resolution, radiation tolerance, and ease of handling.

## 2 Principle of In-Ga-Zn-O thin-film-transistor-based neutron flat-panel detector

Figure 1 depicts a cross section view of the IGZO TFT-based nFPD. The detector comprises a scintillator, a photodiode, an IGZO TFT, and circuits for readout. In this study, a 320 μm thick $^{6}$LiF/ZnS:Ag scintillator sheet (EJ-426HD Eljen Technology, Ltd., USA) was used as the neutron scintillator. $^{6}$Li nuclei in the scintillator capture neutrons and emit α-particles and 3H-particles, with Q value of 4.7 MeV, that are absorbed in the ZnS phosphor. ZnS phosphor emits scintillation photons with peak wavelength of 450 nm. The scintillator sheet is directly coupled on a photodiode pixel array with an IGZO TFT readout, which detects visible light emitted from the scintillator. This IGZO TFT-based nFPD has no fiber-optic plate or other coupling devices on the photodiode array surface with 200 μm pitch pixels. Signals from the photodiode array are digitized to a resolution of 16 bits through an analog front-end circuit and converted into 16-bit TIFF digital images. The acquired image data are transferred to a computer through a USB cable. The external view of the nFPD is shown in Figure 2. The sensor and digital processing parts are separated to prevent the digital processing part from being directly irradiated by the neutron beam. The sensor part has an effective area of 254 mm × 310 mm, which is covered by a 1 mm thick aluminum window. The detector can be easily operated by plugging in a 15 V DC power supply and connecting the USB cable to the computer.

## 3 Experimental Results

Neutron imaging with the IGZO nFPD was tested at compact accelerator driven neutron source (RANS). The sample was placed in front of the detector. Figure 2 depicts a neutron transmission image of a 3.5 inch hard-disk-drive and steel step wedge obtained by the nFPD. Large field of view and high resolution neutron transmission image was obtained in 20 seconds of integration time.

Also, neutron computed tomography experiments conducted at RANS. Neutron 3D CT of a steel bulb was performed using the nFPD. The scene of experiment are shown in Fig.3, and the results are shown in Fig 4. The object was placed on a aluminum rotating stage, and 180 neutron transmission images were taken at a scanning pitch of 2° to cover the entire 360°. Each image was recorded with an exposure time of 20 s, and it took approximately 60 min to obtain a complete set of images. The 3D image was reconstructed from these images using a filtered back-projection algorithm.[4] Through the entire measurement, the detector showed sufficient stability to take 360 images, and high-resolution and high-contrast neutron CT images were successfully reconstructed. As shown in the result, inside of the thick steel can be clearly observed, and moreover, the aluminum part (the rotating stage) which has lower cross section to neutrons become transparent in the result.

## 4 Conclusion

This work is focused on the developing a large field of view neutron imaging detector. The detector has advantages such as radiation tolerance, high neutron sensitivity, large field of view and easy to handle. Furthermore, the low-charge leak of the IGZO TFT ensured long-time exposure, enabling fine neutron imaging and 3D neutron CT using a compact neutron source with a relatively small neutron flux. This simple and easy-to-use nFPD is expected to lower the threshold of neutron imaging and increase the number of neutron users. Moreover, advantage of the nFPD, such as high sensitivity, large FOV, and ease of handle would be also great features for high intensity neutron sources (reactors and spallation neutron sources).

## References


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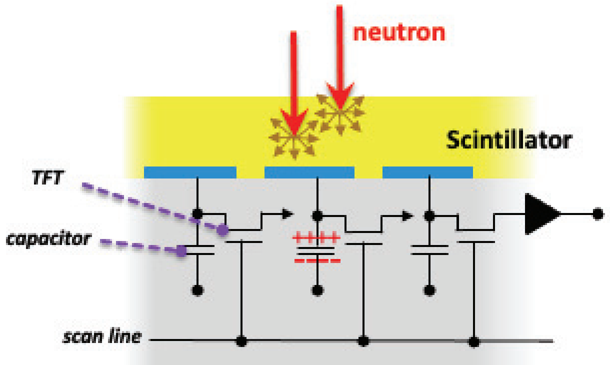


**Fig. 1 Cross section view of the IGZO TFT-based nFPD.**

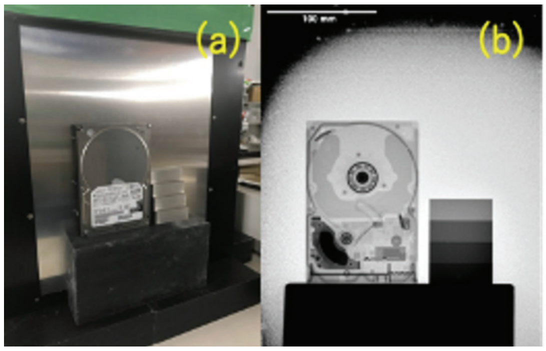


**Fig. 2 (a) Photograph of nFPD and the sample (b) Neutron transmission image obtained by nFPD at RANS.**

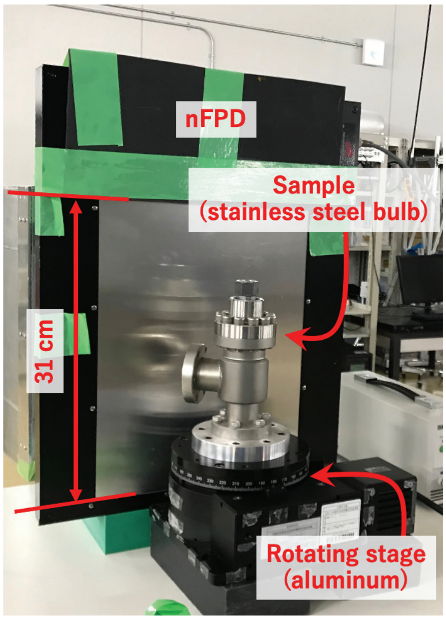


**Fig. 3 Reconstructed neutron CT image of steel bulb taken with nFPD at RANS.**

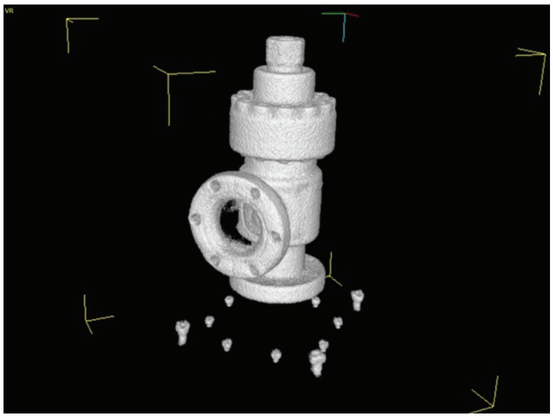

**Fig. 4 Reconstructed neutron CT image of steel bulb taken with nFPD at RANS. Inside of the thick steel object can be clearly observed, while the aluminum part (the rotating stage) which has lower cross section to neutrons become transparent in the result.**