Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2015

Development of energy selective neutron imaging system at HANARO

Jongyul Kim [a*], Jeong ho Kim [a], Suhyun Lee [a], Myung Kook Moon [a], TaeJoo Kim [b], Eun Joo Shin [b], and Wanchuck Woo [b]
[a]*Neutron Instrumentation Division, Korea Atomic Energy Research Institute, Daejeon*
[b]*Neutron Science Division, Korea Atomic Energy Research Institute, Daejeon*
[*]*Corresponding author: kjongyul@kaeri.re.kr*

1. Introduction

Energy selective neutron imaging is one of advanced neutron imaging techniques because it is critical to examine the crystallographic phase distribution and spatial phase transformation for the development and application of new grade high-strength steels using energy selective neutron imaging [1-3]. To perform energy selective neutron imaging, a neutron beam with narrow energy band is needed, and monochromatic thermal and cold neutron beam can be provided as installing a double crystal monochromator or transmission based monochromator at conventional neutron imaging system as shown in Fig 1. In this work, we are developing the energy selective neutron imaging system at the Ex-core Neutron irradiation Facility (ENF) for thermal neutron beam and the 18m Small Angle Neutron Scattering (18mSANS) beam line for cold neutron beam at HANARO.

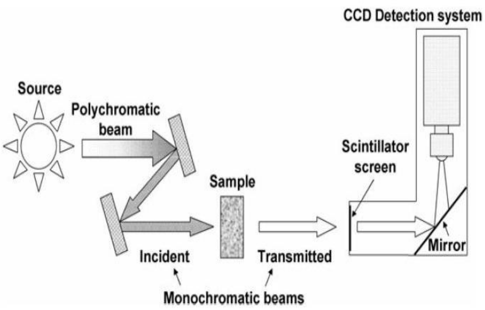

Fig. 1. A schematic of energy selective neutron imaging system

2. Methods and Results

Energy selective imaging system consists of mainly two parts which are a monochromator part for neutron energy selection and a detector part for imaging.

2.1 Transmission based energy selective imaging

To use cold neutron beam, transmission based energy selective imaging system is being developed at the 18mSANS beam line. The velocity selector for neutron energy selection was already installed at 18mSANS. However, the wavelength band has about resolution of $\Delta\lambda/\lambda$=15% which is too broad to map crystallographic phase distribution using energy selective neutron imaging. To make the narrower neutron beam, the transmission based neutron monochromator has been prepared as shown in Fig 2. The transmission based neutron monochromator was designed to have about resolution of $\Delta\lambda/\lambda$=5% when the neutron beam is passing through the velocity selector and transmission based neutron monochromator. The neutron imaging detector consists of a LiF scintillator screen of 50µm thicknesses and an optical CCD camera (2048 x 2048 pixels) with an optical lens. The effective pixel size is about 50µm, and field of view (FOV) is about 10cm x 10cm.

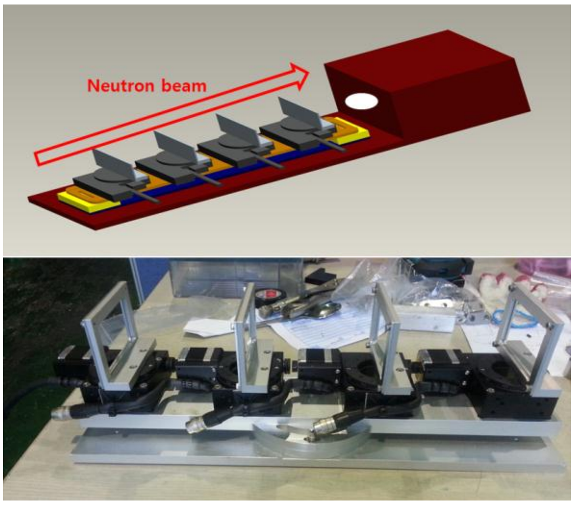

Fig. 2. The assembling drawing (upper) and picture (bottom) of the transmission based neutron monochromator consisted of aluminum plate, monochromator holders, rotation stages, and highly oriented pyrolytic graphite plates.

2.2 Diffraction based energy selective imaging

To use thermal neutron beam, diffraction based energy selective imaging system is being developed at ENF. Neutron imaging experiments using the thermal neutron beam have been performed at ENF, and the double crystal monochromator has been set up for energy selective neutron imaging as shown in Fig 3 [4-5]. The highly oriented pyrolytic graphite plate that may diffract neutrons and X-ray with great efficiency was used, and the mosaic spread is about 0.7°. The double crystal monochromator was designed to have about resolution of $\Delta\lambda/\lambda$=5%. The neutron imaging detector consists of a LiF scintillator screen of 50μm thicknesses and an optical CCD camera (2048 x 2048 pixels) with an optical lens. The effective pixel size is about 50μm, and field of view (FOV) is about 10cm x 10cm. The double crystal monochromator and imaging detector were tested using 5~10keV X-ray instead of neutrons because graphite plate and imaging detector are also used for X-ray, and we confirmed that the prepared double crystal monochromator and imaging detector were working well. When the HANARO is in operation, the neutron spectrum will be measured to confirm resolution of $\Delta\lambda/\lambda$, and neutron imaging performance will be evaluated.

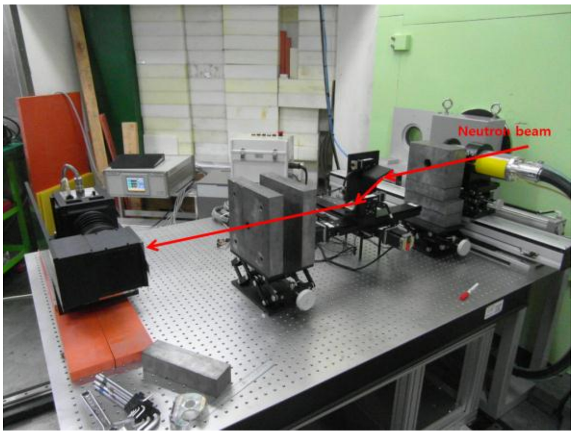

Fig. 3. The picture of the installed double crystal monochromator with imaging detector.

3. Conclusions

The energy selective neutron imaging system is being developed at the ENF and 18mSANS beam line at HANARO. We are expecting to get neutron radiographic images which can distinguish bcc and fcc phases in the prepared sample. The result of energy selective neutron imaging will provide the spatial distribution of the new deformation induced phase, which is important to make a relationship between phase transformation and mechanical behavior of the sample.

REFERENCES

[1] N. Kardjilov et al., New features in cold neutron radiography and tomography Part II: applied energy-selective neutron radiography and tomography, Nucl. Instrum. Methods A 501, 536, 2003.
[2] Lidija Josic et al., Energy selective neutron radiography in material research, Appl. Phys. A 99: 515–522, 2010.
[3] Robin Woracek et al., 3D Mapping of Crystallographic Phase Distribution using Energy-Selective Neutron Tomography, Adv. Mater. 1-5, 2014.
[4] Seung Wook Lee et al., A Neutron Dark-field Imaging Experiment with a Neutron Grating Interferometer at a Thermal Neutron Beam Line at HANARO, J. Korean Phys. Soc. 58, 730734, 2011.
[5] Jongyul Kim et al., Visibility evaluation of a neutron grating interferometer operated with a polychromatic thermal neutron beam, Nucl. Instrum. Methods A 746, 26, 2014