

Performance test of the double crystal monochromator for neutron energy selection

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1. Introduction

A Double Crystal Monochromator (DCM) has been prepared for neutron energy selection at Ex-core Neutron irradiation Facility (ENF) in HANARO research reactor, and has widely used for neutron bragg edge imaging [1-2]. Neutron bragg edge imaging is very powerful technique because the visualization of phase change and distribution in steel sample is possible [3]. The design and mechanical operation of this DCM already introduced in 2015 [4]. However, the performance of the prepared DCM had not tested using neutrons because HANARO had not worked until 2018.05. After restart of HANARO, The performance test was carried out. In this paper, the results of performance test are presented and discussed.

2. Methods and Results

In this section neutron beam spectrum and DCM at ENF are described. The measured neutron beam intensities using DCM are compared with neutron beam spectrum by Time of Flight (TOF) method.

2.1 Neutron beam spectrum of ENF

ENF has polychromatic neutron beam as shown in fig. 1. Using this polychromatic neutron beam, various neutron imaging experiments have been carried out. The ENF neutron beam spectrum was measured using TOF method. The measured neutron beam spectrum of ENF was shaped by silicon and bismuth filter which has been used to filter fast neutrons and gamma-rays, and long tail of spectrum was caused by background signal. The dip in the spectrum corresponds to Bragg-edges from filter materials.

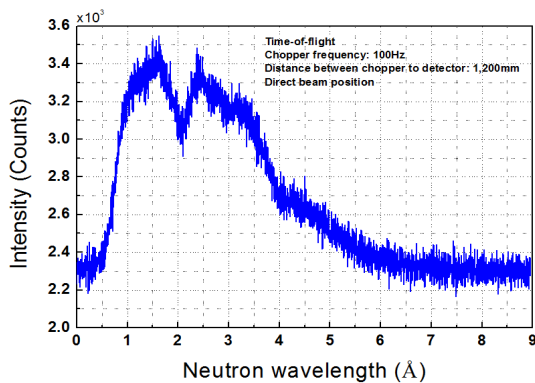


Fig. 1. The measured ENF neutron beam spectrum

2.2 The double crystal monochromator and neutron imaging system

The DCM is consists of two crystal monochromators and 4 motorized stages as shown in Fig. 2. Highly Oriented Pyrolytic Graphites (HOPG) are used as a crystal monochromator because neutrons are diffracted with great efficiency, and the motorized stages are controlled by motion controller at facility outside. Operation principle of DCM is described in Fig. 3. To get monochromatic neutron beam, monochromator tilting angle and position is important and can be obtained using bragg's law. Neutron imaging system is consists of lens coupled CCD camera and ⁶LiF scintillator.

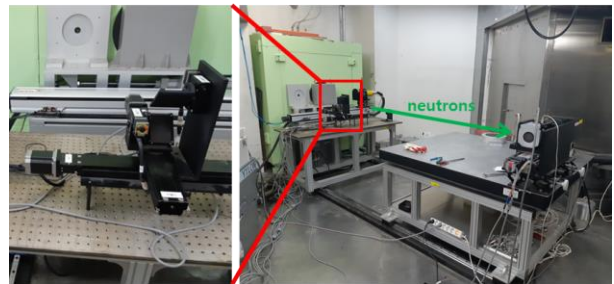


Fig. 2. The double crystal monochromator (left) and neutron imaging system (right)

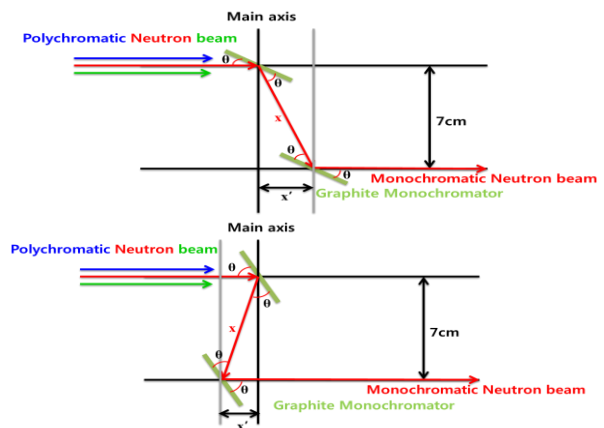


Fig. 3. Operation principle of a double crystal monochroator

2.3 Test results

Energy selected neutron images were obtained by controlling monochromator tilting angle and position from neutron wavelength 2Å to 4.5Å . Obtained neutron images of 2.5Å , 3.0Å , 3.5Å and 4.0Å were shown in Fig. 4. At the same gray scale, we could confirm that neutron image of 2.5Å is brighter than others because

of amount of neutron with 2.5 Å. The energy selected neutron beam size at image plane is about 8cm x 5cm. Neutron beam size is a little bit different in accordance with selected neutron energy because the area that diffracts neutrons is changed by monochromator tilting. The neutron intensities using DCM from neutron wavelength 2Å to 4.5Å were measured from the averaged area value of obtained energy selected neutron images and compared with measured spectrum by TOF as shown in Fig. 5. It is confirmed that the prepared DCM at ENF is working well because similar neutron intensities were measured at a specific neutron wavelength.

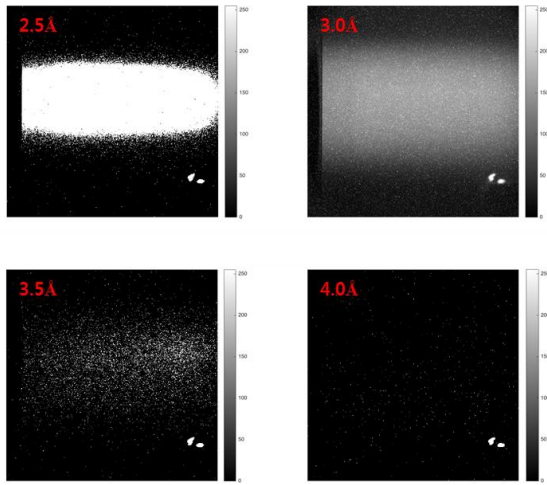


Fig. 4. Obtained neutron images using DCM of 2.5 Å, 3.0 Å, 3.5 Å and 4.0 Å

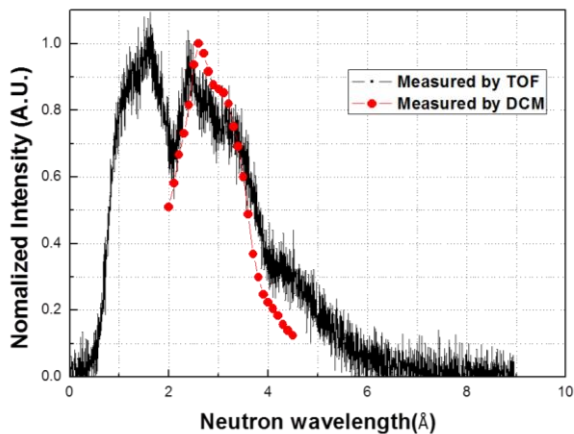


Fig. 5. The measured neutron intensities by DCM

3. Conclusions

We have prepared DCM for neutron bragg edge imaging and confirmed that it is working well using neutron beam at ENF. We have plans to carry out neutron bragg edge imaging experiment with some steel sample during next operation period of HANARO.

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