Energy selective imaging using cold neutron at NIST

Ohsung Oh[a], Youngju Kim[a], Jongyul Kim[b], Myungkook Moon[b], Tae Joo Kim[c], Wan Chuck Woo[c], D.L. Jacobson[d], J.M. Lamanna[d], D.S. Hussey[d], Seung Wook Lee[a*]
[a]*School of Mechanical Engineering, Pusan National University, Busan, Republic of Korea*
[b]*Neutron Instrumentation Division, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea*
[c]*Neutron Science Division, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea*
[d]*Neutron Physics Group, NIST, Gaithersburg, MD, 20899 USA*
[*]*Corresponding author: Seunglee@pusan.ac.kr*

1. Introduction

Radiation imaging using neutron can give special information about the object that x-ray imaging doesn't see. One of the special information is energy selective neutron imaging. This imaging technology uses the Bragg-edges of crystalline materials. So it has advantages that the microstructural information related to the lattice length such as phase and strain without destruction of the objects.

In this paper, energy selective imaging experiment using cold neutron is performed in NG-6 at NIST.

2. Experiments and results

2.1 System configuration

Fig. 1 is neutron imaging system installed in NG-6 at NIST. NG-6 is imaging facility using cold neutron. Total system length is about 8.5 m and sample stage is connected near the detector.

Since neutron beam through the reactor is polychromatic beam, a tunable double-crystal monochromator is installed to get monochromatic beam. And cylinder support that is maintained in vacuum is installed to get more neutron flux.

Fig. 1. System configuration in NG-6 at NIST

2.1 Sample

In this experiment, 4 types of the steel samples are prepared. Each sample is treated to be tensioned gradually so that the phase inside the samples are different.

2.2 Image acquisition

Image acquisition step consist of 4 steps. 1) Three on-sample images and off-sample images per one wavelength are obtained for correction. 2) Images are obtained while changing wave length from 3.3 Å to 4.43 Å per 0.005 Å. Therefore total 207 wavelength images are acquired. 3) 1) and 2) are repeated 3 times. So 9 images are obtained per one wavelength and total number of images obtained through this experiment are 3,726. And image acquisition time per one image is 120 s.

2.3 Image processing

The images get through the neutron imaging system contain errors such as unwanted peaks. To correct these errors, median filter was used. The window size is set to [3,3]. This window size is minimum size we set. The larger window size results in image blurring. Fig. 2 shows the effects of median filter on images.

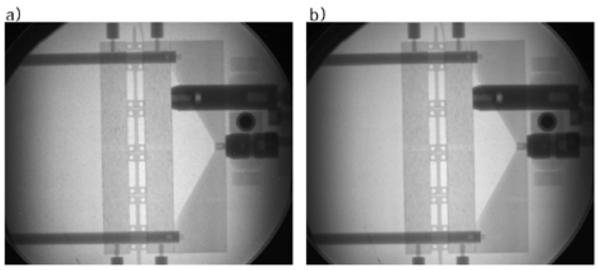

Fig. 2. The effect of median filter; a) Before adjusting median filter, b) After adjusting median filter

After adjusting median filter, white correction is necessary for all images. To correct the images, on-sample images and off-sample images is needed. Therefore, using these images, the corrected images were gotten. Fig. 3 shows the finally corrected image

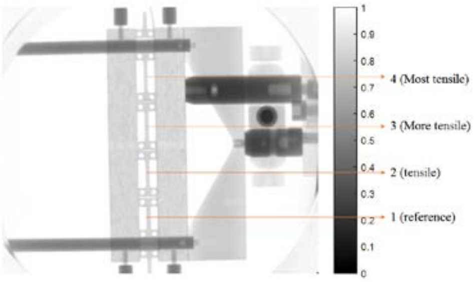

Fig. 3. The corrected image in neutron imaging experiment

2.4 Results

Fig. 4 shows the transmission with samples as a function of the neutron wavelength. In this plot, first line(blue) is reference, second line(red) is partially transformed steel, third line(yellow) is more partially transformed steel, and forth line(purple) is fully transformed sample. From this plot, the decrease of value appear in 4.0 Å and 4.2 Å. So compare this influence, we divided the 4.0 Å image by 4.2 Å image. Fig. 5 shows the divided image result and fig. 6 shows the magnification images of samples, and fig. 7 shows the profile of samples in horizontal direction. In this images, the ratio of samples varies according to the degree of tension.

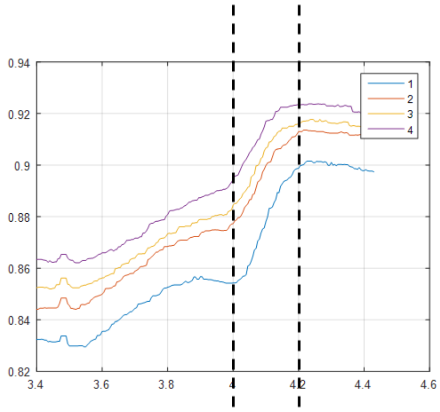

Fig. 4. The transmission value with samples as a function of the neutron wavelength

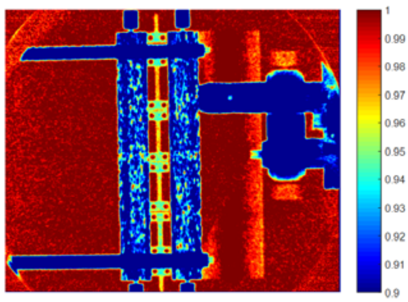

Fig. 5. The image divided 4.0 Å by 4.2 Å

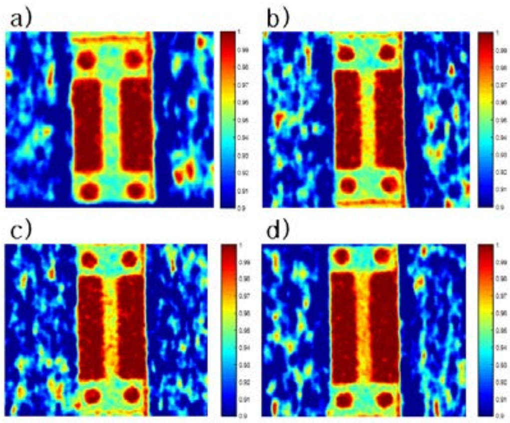

Fig. 6. The magnification images of samples in fig. 5

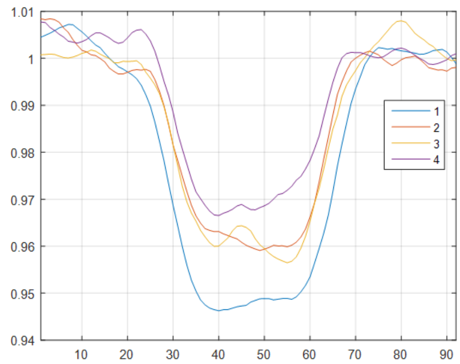

Fig. 7. The profile of samples in horizontal direction

3. Conclusions

Neutron imaging technique can be useful method for internal structure analysis of the materials. This method can be possible to check that the phases of the materials without destruction.

This experimental results are simply divided the two images, but the further analysis and progresses will be proceeded with PNU and NIST.

REFERENCES

[1] R. Woracek, D. Penumadu, N. Kardjilov, A. Hilger, M. Strobl, R. C. Wimpory, I. Manke, and J. Banhart, Neutron Bragg-edge-imaging for strain mapping under in situ tensile loading, Journal of Applied Physics 109, 093506 (2011)

[2] R. Woracek, D. Penumadu, N. Kardjilov, A. Hilger, M. Boin, J. Banhart, and I. Manke, 3D Mapping of Crystallographic Phase Distribution using Energy-Selective Neutron Tomography, Advanced materials 26(24) 4069-4073 (2014)

[3] D.S. Hussey, C. Brocker, J.C. Cook, D.L Jacobson, T.R. Gentile, W.C. Chen, E. Baltic, D.V. Baxter, J. Doskow, and M. Arif, A New Cold Neutron Imaging Instrument at NIST, Physics Procedia 69, 48-54 (2015)