(General use)

MLF Experimental Report	Date of Report 2014/5/26
Project No. 2013B0017 Title of experiment Magnetic field imaging and Bragg-edge transmission using a high-resolution, time-resolved neutron imaging detector based on the muPIC micro-pixel chamber Name of principal investigator PARKER Joseph Don Affiliation Kyoto University (*currently CROSS-Tokai)	Name of person responsible for instrument OIKAWA Kenichi, HARADA Masahide Name of Instrument/(BL No.) NOBORU (BL10) Date of Experiment 2014/3/17-19

Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. Name of sample(s) and chemical formula, or compositions including physical form.

We prepared a total of four samples for the experiment, consisting of Permalloy C metal (Ni 77%/Fe 14%/Cu 5%/Mo 4%) in 5cm x 5cm sheets with thicknesses of 0.2mm (2 sheets) and 0.5mm (2 sheets). Two sheets (one of each thickness) were heat treated to optimize their magnetic shielding properties.

During the experiment, we also imaged samples provided by collaborator T. Shinohara consisting of a soft magnetic iron-alloy foil (amorphous ribbon) with a thickness of 30 μm. One sample was heat treated, while the other was not.

2. Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

The experimental plan called for imaging a Permalloy sample using both magnetic imaging with polarized neutrons and Bragg-edge imaging using the μPIC-based time-resolved neutron imaging detector (μNID). The sample would be measured twice, before and after bending, allowing us to image the changes in both the magnetic domain structure and the physical crystal structure caused by the bending. Using the μNID, we can achieve a spatial resolution of about 0.1mm. Polarized neutrons were provided by a polarizing apparatus consisting of a super-mirror polarizer, spin flipper, two sets of two spin-rotator coils, super-mirror analyzer, and collimator. A magnetically shielded sample environment was also provided between the two sets of spin rotators. The combined polarization apparatus has a total length of about 1.7 m. The μNID was set about 30 cm downstream of the collimator and about 1 m from the sample position. The beam line setup was as follows: rotary collimator large, duct-end collimator 32 x 32 mm_2, upstream/downstream B_4C slits 25 mm (y) x 18 mm (x).

2. Experimental method and results (continued)

We began by measuring the heat-treated 0.2mm Permalloy sample. Unfortunately, we were not able to measure any magnetic field in the sample. We tried various combinations of incident and transmitted spin orientations (XX, YY, YZ, etc.) and even placed the sample inside a coil to create a guide field, but we were unable to produce any contrast in the image. We are now studying the data to try and learn the reason for the failure to image the magnetic field of the sample. Possible reasons are: the magnetic domains are too small, the sample is too thick, or our data analysis method is too simple or incomplete.

As a backup, we imaged a 30μm-thick amorphous foil composed of a soft magnetic iron alloy. Two samples were measured, one with heat treatment and one without. Similar samples were measured previously using the same polarizing setup and an RPMT as the imaging detector. The RPMT has limited spatial resolution of only about 0.8mm. Then, we can hope to see more detail using the μNID with a spatial resolution of about 0.1mm.

The two samples were measured for each of nine incident and transmitted neutron spin combinations (XX, YY, ZZ, XY, XZ, …), with the spin flipper on and off, for a total of 18 measurements. Each of these measurements was carried out for 45 minutes, for a total of 13.5 hours measurement time per sample. The polarization of the transmitted neutron beam could then be calculated for each spin combination as:

$$\mathrm{P(TOF)} = \frac{N_{sfon}(TOF) - N_{sfoff}(TOF)}{N_{sfon}(TOF) + N_{sfoff}(TOF)}$$

where $N_{sfon}(TOF), N_{sfoff}(\mathrm{TOF})$ are the measured neutron time-of-flight spectra with the spin flipper on and off, respectively. Figure 1 shows preliminary two-dimensional XX polarization distributions measured for the foils without (left) and with (right) heat treatment for neutron TOF of 20 to 21 ms and a spatial resolution of about 0.3 mm. The untreated sample shows a strong preference of the magnetic domains along the direction in which the ribbon was drawn, while the heat treated sample shows no such preference. A more detailed analysis including improved spatial resolution is ongoing.

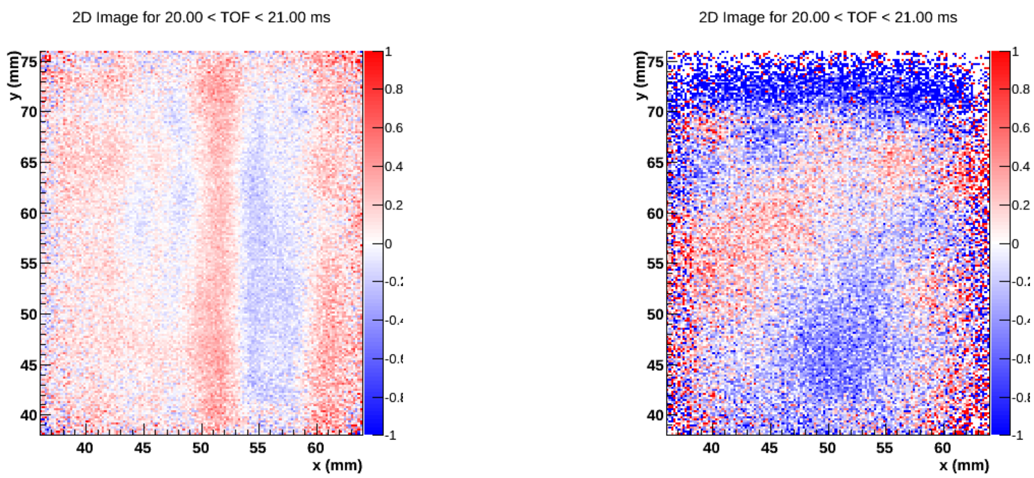

Figure1. Two-dimensional XX polarization distributions for neutron TOF between 20 and 21 ms for amorphous foil samples without (left) and with (right) heat treatment.