実験報告書様式（一般利用課題・成果公開利用）

（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

J-PARC MLF Experimental Report	提出日 Date of Report May 10, 2013
課題番号 Project No. 2012B0218 実験課題名 Title of experiment High resolution transmission Bragg edge imaging and neutron resonance absorption imaging 実験責任者名 Name of principal investigator Anton Tremsin 所属 Affiliation University of California at Berkeley	装置責任者 Name of responsible person K. Oikawa 装置名 Name of Instrument/(BL No.) Noboru (BL10) 実施日 Date of Experiment January, 2013

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）

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

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

Steel samples for residual stress measurements (Fe)

Ni single crystal rods (Ni/Al alloy)

Au, Ag, Ta, Cu, Cd, Co for resonance absorption imaging

Japanese sword

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）

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

The single crystal Ni rods were studied for the uniformity of crystal orientation within the sample. Strong modulation of transmission diffraction pattern was studied by high resolution energy resolved imaging with time resolution of 21 μs per energy slice and spatial resolution of 55 μm.

The Samples of steel (including Japanese sword) were imaged for the residual strain studies. The two metal compositions were observed for the internal and external part of the blade. Single microcrystallites on a sub-mm scale were clearly resolved at the interface between the two blade metal compositions.

Resonance absorption imaging was performed with high spatial (55 μm) and temporal (20 ns) resolution for each neutron detected. For the first time combination of high spatial resolution and timing resolution allowed spatially resolved imaging of resonance peaks to the energy of 10-30 keV. The structure of the double proton pulse is clearly resolved.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

The possibility to detect simultaneous multiple neutrons with both high spatial and temporal resolutions provided by our MCP/Timepix detector was exploited in the experiments on energy resolved imaging in the wide range of neutron energies: starting with epithermal neutrons of keV energies and to the cold neutrons available at the NOBORU beamline. We established the limit of neutron energy at which resonance transmission imaging can still be performed with our instrumentation and J-PARC beamlines. Many engineering materials do not exhibit resonances at energies below ~1 keV and therefore the quality of experimental data in terms of spectral resolution, useful statistics (events above the background level), spatial resolution and isotopic specificity become very important for experiments utilizing resonances of relatively high energies. Crucial for the experiments conducted was the quality of the NOBORU beamline with its intense and relatively narrow proton pulses of 100 ns each separated by 600 ns combined with the intrinsic 10 ns timing resolution of our detector. Another important factor was the very low level of background noise at the beamline as well as in the detector itself, allowing for reasonable signal-to-noise ratios for energies exceeding 10 keV. The spatial resolution of isotope specific imaging with our setup was confirmed to be on the scale of ~150 µm for various materials when samples are mounted ~15 mm from the active area of the detector. The measured transmission spectra in principle can be extracted for each 55x55 μm^2 pixel of our detector, providing there are sufficient counts per pixel. However, the flexibility of post-experiment data analysis can be used to compromise between the spatial resolution and the accuracy of measured spectra by grouping the pixels together. The accurate transmission spectra can then be used to quantify the amount of isotopic concentration in a sample to very small quantities for materials with strong resonances in the range of measurable energies. The fitting of theoretical transmission convolved with the shape of the neutron pulse at a given energy into the experimental data proved to be quite accurate for the reconstruction of isotope concentration in the samples along the direction of the beam.

Although in the present study we could not accurately measure the shape of the neutron pulse we have demonstrated how the sharp resonance features of known materials can be used to calibrate the width of the neutron pulse. The results of our measurements are in good agreement with the pulse width values predicted for the NOBORU beamline. Materials with few isolated strong resonances, rather than with many overlapping resonances observed for copper in the present experiments will be preferred for the future measurements of neutron pulse width as a function of neutron energy. A single proton pulse mode will also be desirable for the accurate neutron pulse shape analysis.

The detection efficiency of our detector was measured to be 70% for the cold neutrons and is likely to be ~2 % level for 5 eV neutrons and only 0.2% for 50 eV energies, if only interaction with 10B is taken into account. The low detection efficiency, however, is partially compensated by the existence of a relatively high flux produced by the spallation source at the epithermal energies. The integration time required for the resonance transmission imaging with our current detector is in the minutes to an hour range. Another possibility in improving the statistical accuray is the elimination of the Bismuth filter used in the present experiment, which reduces the intensity of the beam by as much as 80%. The Timepix electronics should potentially survive the high dose of gamma radiation, although a detailed study of the stability of our detector with no gamma filter is needed before we can safely operate the detector with full direct beam.