（ ※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。 ）

MLF Experimental Report

提出日 Date of Report

課題番号 Project No.
2014B0026

実験課題名 Title of experiment
2D/3D Neutron Imaging Characterization for Microstructure and Plastic Forming of Steels

実験責任者名 Name of principal investigator
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装置責任者 Name of responsible person
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装置名 Name of Instrument/（BL No.）
BL10

実施日 Date of Experiment
2014/12/12 21:00 - 12/15 9:00

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.

Name	**Chemical formula** mass%	**State**	**Quantity**
Ferrite steel / Fe-Si	Fe-0.5Si	Solid	15 × 6 × 200 mm^3, 140g
Austenite steel / SUS310	Fe-20Ni-25Cr	Solid	15 × 6 × 200 mm^3, 140g
Duplex stainless steel / SUS329J	Fe-7Ni-25Cr	Solid	15 × 6 × 200 mm^3, 140g
Austenite steel / Fe-25Ni-0.4C	Fe-25Ni-0.4C	Solid	15 × 6 × 200 mm^3, 140g

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。）

【Purpose】

The purpose of the study was to visualize microstructure of the engineering products using the Bragg-edge transmission (BET) imaging technique.

【Background】

The BET imaging using pulsed neutron is a non-destructive testing technique in various fields and is an excellent method for visualizing the spatial distributions of crystalline structure in relatively thicker materials. Bending is a common and vital forming mode in manufacturing industry, which simultaneously includes tension and compression deformation. We applied this technique to clarify the distribution of microstructure in the bent steel plates.

【Experimental】

Neutron imaging experiment was carried out at NOBORU, BL10 of MLF at J-PARC. Four kinds of steel materials, 1) a ferrite single-phase steel, 2) an austenite single-phase steel, 3) a hot-rolled duplex stainless steel, and 4) a metastable austenitic steel were selected in this study. The samples were prepared in NIDAK Corporation by three-point bending at room temperature with a rectangular bar with size of 12× 13 × 250 mm^3. A Gas Electron Multiplier (GEM) detector was used for two-dimensional (2D) transmission spectra using time-of-flight method. The flight path length from the neutron source to the detector position was 14.14 m. The measured Bragg-edge spectra were analyzed by RITS (Rietveld Imaging of Transmission Spectra) code. Quantitative 2D mappings of crystallographic texture, crystallite size and phase distribution were provided by the non-destructive transmission technique.

【Preliminary Result】

Figure 1(a) shows a measured 2D radiographic image of a ferrite (α-Fe, BCC structure) steel. Figure 1(b) shows the measured and fitted transmission spectra extracted from the indicated inner and outer regions in Fig. 1(a). These two Bragg-edge patterns show clear difference in shape due to the variation of texture.

(a) **(b)**

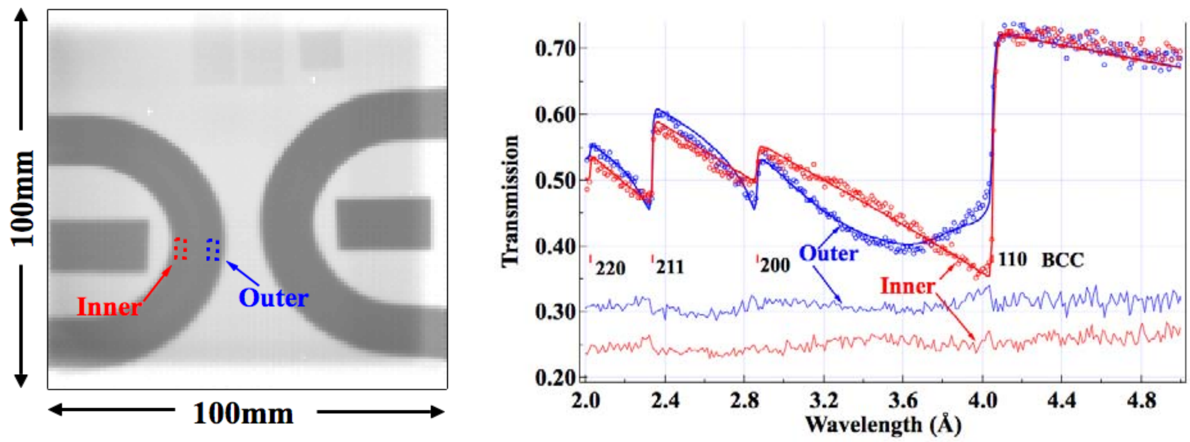

Figure1 Examples of BET imaging results of the ferrite single-phase steel: (a) radiographic image and (b) BET spectra obtained at positions indicated in (a). The markers and solid lines represent the observed and calculated data, respectively. The differences between the observed and calculated data are shown beneath each plot, with the differences for the inner and outer offset by 0.25 and 0.31, respectively.

The March–Dollase (MD) function coefficient R can be determined from BET spectra analysis by the RITS (Rietveld Imaging of Transmission Spectra) code. It provides the degree of the preferred orientation, where R = 1 for a random texture sample and R < 1 ([HKL] // beam) or R > 1 ([HKL] ⊥ beam) for a textured sample, and [HKL] represents preferred orientation vector. Figure 2 shows the 2D map of the refined coefficient R for ferrite [750] of the ferrite steel. As seen, the R decreases gradually from the outer to the inner zone in the beam direction of the bent sample, which suggests that the [750] orientation is perpendicular to the beam direction in the outer zone while it becomes parallel in the inner zone. That is, the [750] texture is weak in the beam direction the outer zone and becomes strong to the inner zone. Texture variations through the whole sample due to bending deformation are successfully visualized by BET imaging method.

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

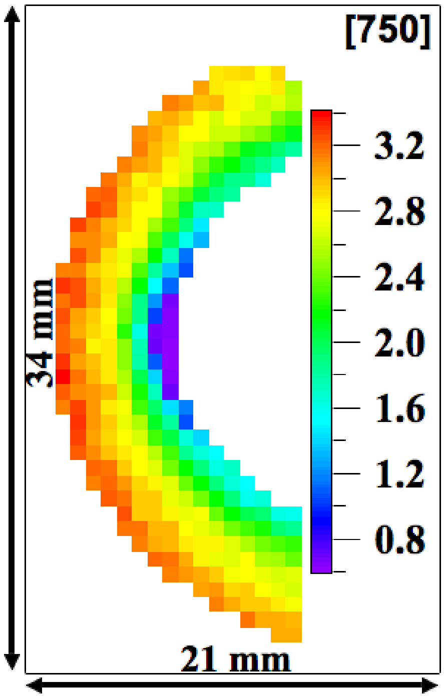

Figure 2 2D map of texture variations for the ferrite steel determined by BET imaging.