（ ※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。）

CROSS TOKAI Experimental Report J-PARC	承認日Date of Approval 2016.6.8 承認者Approver Takenao Shinohara 提出日Date of Report 2016.6.7
課題番号 Project No. 2015A0151 実験課題名 Title of experiment Nondestructive study of traditional Japanese forged iron artifacts using pulsed neutron imaging for evaluating crystallographic texture and microstructure and investigating their manufacturing techniques 実験責任者名 Name of principal investigator Manako Tanaka 所属 Affiliation Tokyo University of the Arts	装置責任者 Name of responsible person Takenao Shinohara 装置名 Name of Instrument/（BL No.） BL22 実施日 Date of Experiment 11/06/2015～11/12/2015

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.

(1) Japanese matchlock gun, Fe, solid
(2) Fragments of Japanese matchlock gun, Fe, solid
(3) Fragments of Japanese matchlock gun, Fe, solid
(4) Fragments of Japanese sword manufactured by the Mino school, Fe, solid
(5) Fragments of Japanese sword manufactured by the Mino school, Fe, solid
(6) Fragments of Japanese sword manufactured by the Mino school, Fe, solid
(7) Fragments of Japanese sword, Fe, solid
(8) Reproduction sample of Japanese sword, Fe, solid
(9) Reproduction sample of Japanese sword, Fe, solid

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.

【Experimental method】

The experiment was carried out by the pulsed neutron imaging using the TOF method (Fig.1) and also by neutron CT at J-PARC/MLF BL22. A 2D-PSD, nGEM (the spatial resolution: 800μm, detection area: 10cm×10 cm), was used to get the spatial dependent TOF data and CCD camera was used for CT.

【Results】

Although there was a trouble at J-PARC and a postponement of the experiment, the experiment itself was conducted as planned. First, we analyzed Fragments of Japanese swords manufactured by

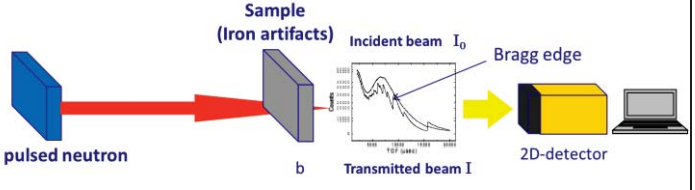
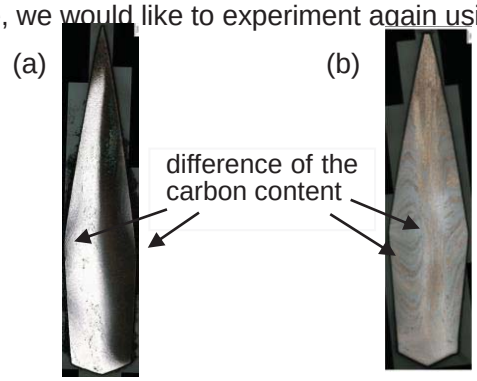


Fig.1. Experimental layout of the pulsed neutron

the Mino school, reproduction sample of Japanese sword by the pulsed neutron imaging. One of the aim of the experiment was to compare the results by nondestructive methods using pulsed neutron with the results by destructive methods and to accumulate the fundamental data of crystallographic information for the systematic measurement of Japanese iron artifacts in the future. The microstructure of the fragments of Japanese sword manufactured by the Mino school were already observed by optical microscope. Those swords show distinctive features of microstructure as shown in Fig.2. Now we are just in the middle of analyzing the data obtained from pulsed neutron TOF methods and checking how detailed information on microstructure such as and strain, and carbon content can be got by Bragg edge analysis.

Secondly, we analyzed fragments of Japanese swords manufactured by the Mino school, reproduction sample of Japanese sword, and the whole area of Japanese matchlock gun, and so on by using neutron CT. Our results so far have proved the efficacy of the pulsed neutron imaging methods, but we thought that to carry out the neutron CT experiment is also very useful to grasp the inner structure and metallurgical characteristics three-dimensionally. Fig.3 and Fig.4 show obtained neutron CT image of Japanese swords manufactured by the Mino school and Japanese matchlock gun. By comparing the neutron CT images and the microscopic images, it became clear that by using neutron CT, we can identify the differences of the carbon content (α-Fe and perlite) and the area and the depth of the quenching (martensite) of Japanese swords, and the conjugation method of Japanese matchlock gun due to the light and shade nondestructively. On the other hand, because of the spatial resolution, differences of the carbon content in a very small area (Fig.2 (b)) could not be identified this time. In the future, we would like to experiment again using higher resolution neutron CT.



Fig,2 Optical microscope of the fragments of Japanese sword manufactured by the Mino school

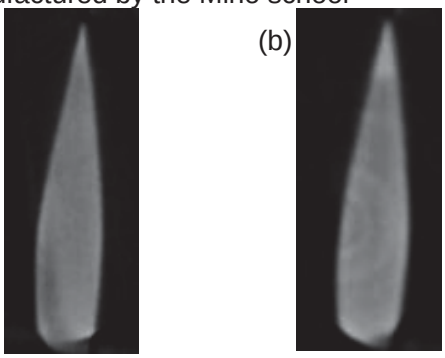


Fig.3 Neutron CT of the fragments of Japanese sword manufactured by the Mino school (the same samples as Fig.2).

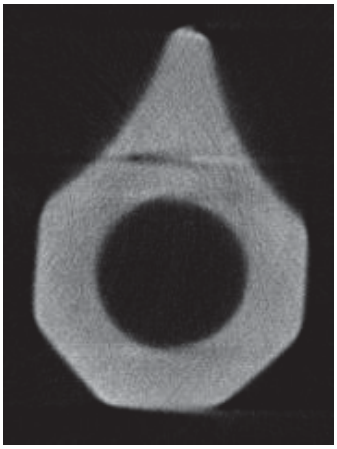


Fig.3 Neutron CT of Japanese matchlock gun