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。）

CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval 2013/11/23 承認者 Approver Jun-ichi SUZUKI 提出日 Date of Report 2013/05/21
課題番号 Project No. 2012B0152 実験課題名 Title of experiment Characterization of Co-precipitation in High-Strength Low-Carbon Steel using Alloy Contrast Variation Method 実験責任者名 Name of principal investigator Yojiro Oba 所属 Affiliation Kyoto University Research Reactor Institute	装置責任者 Name of Instrument scientist Jun-ichi Suzuki 装置名 Name of Instrument/(BL No.) TAIKAN (BL-15) 実施日 Date of Experiment 25/2/2013-28/2/2013

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.

The samples were vanadium (V)-copper (Cu) steels, V steels, and Cu steels. The chemical compositions are summarized in Table 1. The matrices of all the samples were ferrite. The thicknesses of the samples were about 2 mm.

Table 1 Chemical compositions of the samples (mass %).

	C	V	Cu
V steel	0.04	0.20	-
Cu steel	-	-	1.00
V-Cu steel	0.04	0.20	1.00

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.

In this study, the characterization of vanadium carbide and copper precipitates in low-carbon steels were investigated using small-angle neutron scattering (SANS). The SANS experiments were performed at the TAIKAN. In order to separate the nuclear scattering and magnetic scattering, a magnetic field of 0.5 T was applied using a permanent magnet. The data obtained were reduced using the data reduction software installed at the TAIKAN. In the case of ferritic steels, multiple Bragg scattering occurs at the wavelength shorter than 0.4 nm. To avoid the contamination of the SANS profiles with the multiple Bragg scattering, the scattering data with the wavelength longer than 0.4 nm were analyzed.

Figure 1 shows the SANS profiles of the samples. The profiles were obtained between q=0.08 and 3 nm^{-1}. Here, q is the momentum transfer and equal to $(4\pi/\lambda)\sin\theta$, where λ and θ are the wavelength and half the scattering angle, respectively. The SANS profiles of the V-Cu and the Cu steels has a clear shoulder around q=0.4 nm^{-1}. This characteristic corresponds to the scattering of the precipitates. On the other hand, the SANS profile of the V steel has no shoulder. This indicates that the amount of the precipitates is very low and/or the precipitates have wide size distribution. Therefore, the main component of the shoulder observed in the SANS profiles is probably the scattering of the Cu precipitates. The difference between the SANS profiles of the V-Cu and the Cu steels is attributed to the addition of vanadium and carbon. In the q region lower than 0.4 nm^{-1}, the intensity of the Cu steel is higher than that of the V-Cu steel. This is probably due to the decrease in the amount of precipitates and/or the change in the chemical composition of precipitates.

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

This clearly indicates that the addition of vanadium and carbon affects the morphology of the precipitates. In the *q* region higher than 0.4 nm^{-1}, the intensity of the V-Cu steel is below that of the Cu steels. However, we can not determine whether this indicates any new morphology provided by vanadium and carbon or just a simple coexistence of the vanadium carbides and the Cu precipitates. For further investigation, small-angle X-ray scattering (SAXS) is planned. Combined use of the SANS and SAXS provides the information about the chemical composition of the precipitates.[1,2]

Next, the size of the precipitates in the V-Cu steel was roughly estimated using curve fit analysis. As the fitting model, spherical particles with a logarithmic normal size distribution was assumed. The results show the average radius of the precipitates is about 3.6 nm. Based on the above discussion, this value mainly reflects the size of the Cu precipitates.

In the transmission spectra of the samples, a clear Bragg-edge of {110} crystal lattice plane was observed (Fig. 2). The shape of the Bragg-edge transmission in the V-Cu steel is similar to that of the V steel, whereas that of the Cu steel shows smaller jump than the others. This difference is probably because of the difference in the crystal grain size of the matrix.[3]

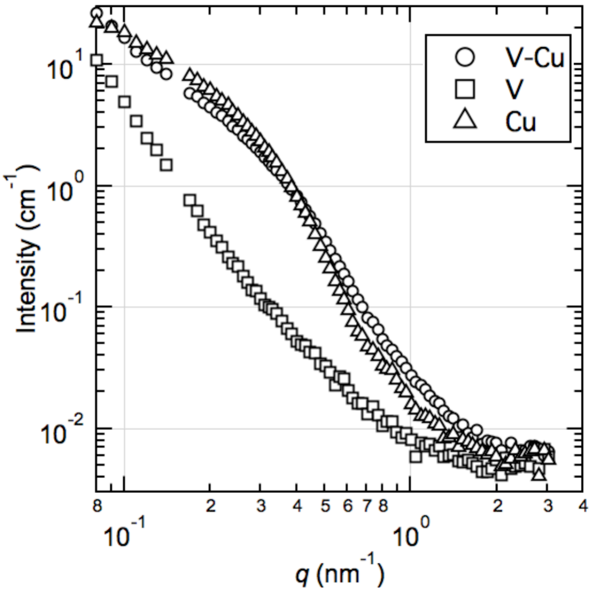

Fig. 1 SANS profiles of the V-Cu, V and Cu steels.

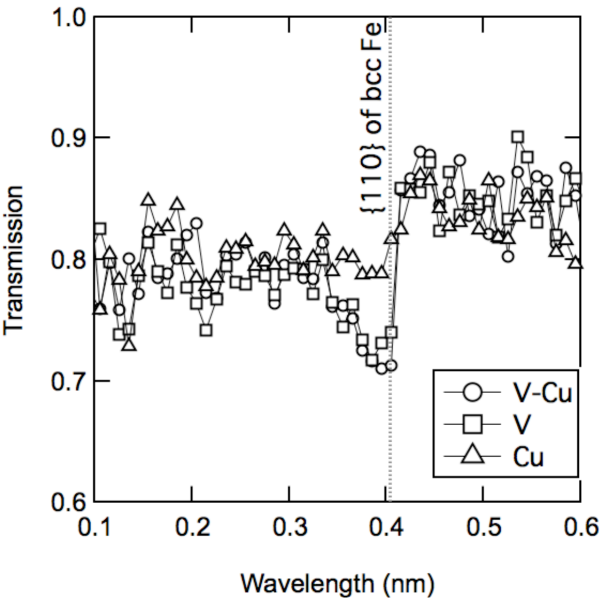

Fig. 2 Transmission spectra of the V-Cu, V and Cu steels. The dotted line corresponds to the Bragg-edge of {110} plane in bcc Fe.

[1] V. Gerold, J. E. Epperson and G. Kostorz, J. Appl. Cryst. 10 (1977) 28.
[2] M. Ohnuma, J. Suzuki, S. Ohtsuka, S.-W. Kim, T. Kaito, M. Inoue and H. Kitazawa, Acta Mater. 57 (2009) 5571.
[3] H. Sato, T. Kamiyama and Y. Kiyanagi, Mater. Trans. 52 (2011) 1294.