MLF Experimental Report	提出日 Date of Report 2017.3.29
課題番号 Project No. 2015A0044 実験課題名 Title of experiment Effect of deformation history on TRIP effect in TRIP-aided multi-microstructure steels 実験責任者名 Name of principal investigator Noriyuki Tsuchida 所属 Affiliation University of Hyogo	装置責任者 Name of responsible person Stefanus Harjo 装置名 Name of Instrument/(BL No.) J-PARC, TAKUMI, BL19 実施日 Date of Experiment 2016.4.17, 9:00 ～2016.4.20, 0:00

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.

In this experiment, the following steel was used.

- Fe-0.2C-1.5Si-1.2Mn（0.2C TRIP steel）

Table Chemical composition of a 0.2C TRIP steel (mass%).

Steels	C	Si	Mn	P	S	Al
0.2C TRIP	0.211	1.51	1.22	0.022	0.0025	0.039

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**

TRIP-aided multi-microstructure steel obtained by a 0.2C-1.5Si-1.2Mn steel (0.2C TRIP steel) was used in this study. Static tensile tests were carried out at an initial strain rate of 3.3×10^{-4} s^{-1} at various temperatures between 123 and 373 K to make clear the effect of temperature on TRIP effect. The tensile tests at which test temperature is changed during deformation (temperature change test) were also been conducted. From the temperature change tests, the deformation history that the excellent uniform elongation can be obtained was summarized. The test specimens with various true strains in the condition that the excellent uniform elongation was obtained in the temperature change tests were prepared. Using those specimens, ex-situ neutron diffraction experiments are performed with TAKUMI at JAEA. Data analyses were performed by using a Rietveld software, which is so-called Z-Rietveld. In this study, the deformation-induced martensitic transformation behavior were summarized in addition to the phase and lattice strains in austenite and ferrite phases.

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

● Experimental results

Figure 1 shows the nominal stress-strain curve obtained by the static tensile test at 296 K (blue) and that by the temperature change test (red). The 0.2% proof strength, tensile strength and uniform elongation obtained by the tensile test at 296 K are 399 MPa, 740 MPa, 32.4 %, respectively. The tensile strength and uniform elongation obtained by the temperature change test are 785 MPa and 51 %. Especially, the uniform elongation obtained by the temperature change test was 1.5 times larger than that obtained by the static tensile test at 296 K. It is found from the temperature change test in Fig. 1 that the 0.2C TRIP steel fulfils its potential of improvement of ductility due to TRIP effect.

Figure 2 shows the volume fraction of deformation-induced martensite ($V\alpha$) as a function of true strain in the static tensile test at 296 K (blue) and the temperature change test (red) in **Fig. 1**. In the case of static tensile test at 296 K, the $V\alpha$ at true strain of about 0.27, which is close to the uniform elonagtion, was about 5%. This is about half of the volume fraction of retained austenite (10.6%). On the other hand, about 90 % of retained austenite was transformed to deformation-induced martensite at near uniform elongation in the temperature change test (red). Furthermore, the higher deformation-induced martensitic transformation rate maintained until the maximum load point in the temperature change test (average transformation rate at true strains between 0.3 and 0.4, in which the work-hardening rate increased largely, was 0.2).

From the above results, the enhancement of uniform elongation by the temperature change test in the 0.2C TRIP steel can be seen. Furthermore, the present ex-situ neutron diffraction experiment can discuss the deformation-induced transformation behavior in the temperature change test quantitatively. The change of volume fraction of deformation-induced martensite as seen in **Fig. 2** seems to be of essential importance in the further understanding of TRIP effect.

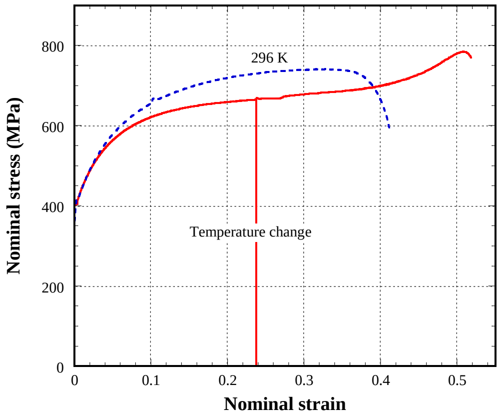

Fig. 1 Nominal stress-strain curves obtained by the static tensile test at 296 K and the temperature change test in a 0.2C TRIP steel.

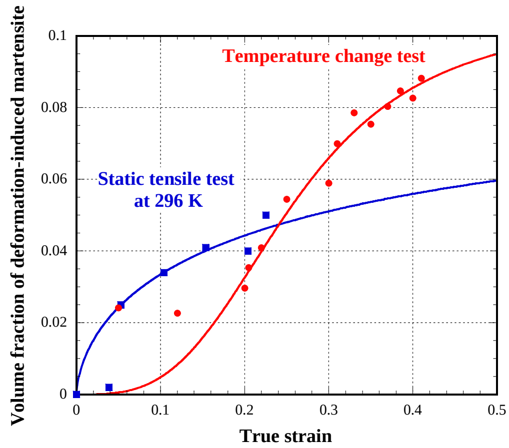

Fig. 2 Volume fraction of deformation-induced martensite as a function of true strain obtained by the static tensile test at 296 K and the temperature change test in a 0.2C TRIP steel.