（ ※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 Aug 26, 2016
課題番号 Project No. 2014B0299 実験課題名 Title of experiment Uniaxial Strain Dependence of Critical Current and Its Asymmetric Behavior in Practical Superconducting Wires 実験責任者名 Name of principal investigator Kozo Osamura 所属 Affiliation Research Institute for Applies Sciences	装置責任者 Name of responsible person Harjo Stefanus 装置名 Name of Instrument/（BL No.） BL-19 (TAKUMI) 実施日 Date of Experiment Oct 28 9:00 – Nov 2 9:00, 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. ITER NB3Sn wires including Nb_3Sn filaments, Cu-Sn matrix and Cu stabilizer
2. REBCO tapes including (Y, Gd)$Ba_2Cu_3O_x$ layer, Hastelloy substrate and Cu stabilizer
3. BSCCO tapes including $(Bi, Pb)_2Sr_2Ca_2Cu_3O_{10}$, Ag matrix and Ni alloy reinforcing member

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 samples used here were three kinds of practical SC wires: Nb_3Sn, REBCO and BSCCO. Two kinds of sample holder were employed. The first one was used to measure precisely the lattice constant as a function of temperature. The second was used in order to measure uniaxial strain state exerted on SC components when applying the tensile load at low temperature. In the present study, as a first step of our project, we carried out the diffraction experiments at low temperature less than 6 K and at room temperature for two series of Nb_3Sn wires applied different heat treatments as well as the diffraction experiments at room temperature for the practical REBCO and BSCCO wires.

Nb_3Sn wires made by the restacked-rod process (RRP®) have reached very high values of critical-current density J_c that make them the prime candidates for use in the high-luminosity upgrade of the Large Hadron Collider (LHC). In a recent study, we revealed a precipitous change in the intrinsic irreversible strain limit $\varepsilon_{rr,0}$ of RRP® wires with heat-treatment temperature. This behavior, named the *strain irreversibility cliff* (SIC), happens over a temperature range of less than 20 °C, with the major part of the cliff (i.e. 0.05 % ≤ $\varepsilon_{irr,0}$ ≤ 0.3 %)

occurring over a temperature range of 10 °C or less. This origin of SIC is suggested to relate either the phase transition of Nb_3Sn phase or the brittleness relating with secondary phases. In order to elucidate the true origin, we carried out the diffraction experiments at both the low temperature less than the transition temperature of Nb_3Sn phase and the room temperature.

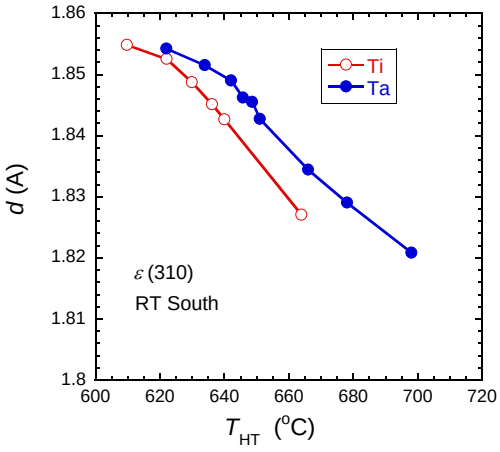

Fig. 1 Heat treatment temperature dependence of (310) lattice spacing of epsilon phase in two Nb_3Sn wires doped with Ti or Ta.

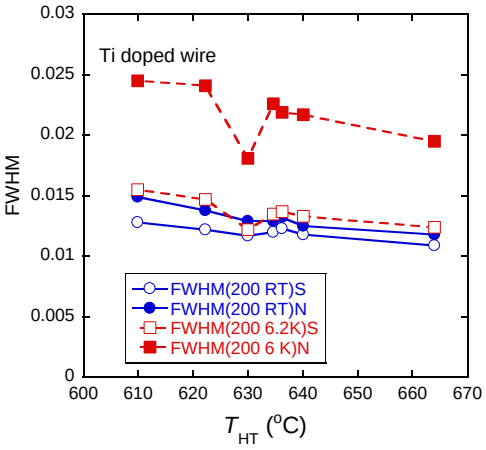

Fig. 2 Heat treatment temperature dependence of FWHM of Nb_3Sn (200) diffraction peaks measured at 6 K and room temperature for Ti doped Nb_3Sn wire

As shown in Fig. 1, the lattice spacing of epsilon Cu_3Sn secondary phase decreased with increasing heat treatment temperature. This decrease is suggested to accompany the increase of solute concentration in the matrix, which attributes to the recovery of ductility of the wire. Fig. 2 indicates the change of full width of half maximum (FWHM) of Nb_3Sn superconducting phase. By using the present pulsed neutrons, it is possible to get information simultaneously both along the axial and transverse directions of wires as indicated by S and N, respectively in Fig. 2. The FWHM along the transverse direction of wires became large at 6 K. This suggests a possibility to relate with the tetragonal phase transition from the cubic phase. Even though we cannot get any conclusion, the present interesting results will be reported at the international conference, ASC2016 held in Denver on Sept 9, 2016.

As the second preliminary experiment, we attempted to measure the diffraction from the REBCO tapes including (Y, Gd)$Ba_2Cu_3O_x$ layer. Even though the SC layer includes the rare earth element, we succeeded to obtain clear diffraction peaks with (020) and (200) crystal planes. It is great advantage in the next step for measuring of local strain exerted on the superconducting layer as a function of external strain for the practical REBCO tapes. Further it was confirmed to be possible to measure the similar diffraction intensities for the BSCCO tapes including (Bi, Pb)$_2Sr_2Ca_2Cu_3O_{10}$, Ag matrix and Ni alloy reinforcing member by using the present experimental technique. So we could establish a foothold to study the uniaxial strain dependence of critical current and tts asymmetric behavior in practical superconducting wires.