MLF Experimental Report	提出日 Date of Report 2014/10/09
課題番号 Project No. 2009A0085 実験課題名 Title of experiment: Stress/ Strain Effects on Industrial Superconducting Composites 実験責任者名 Name of principal investigator Stefanus Harjo 所属 Affiliation: J-PARC Center, JAEA	装置責任者 Name of responsible person Kazuya Aizawa, Stefanus Harjo 装置名 Name of Instrument/(BL No.) TAKUMI (BL19) 実施日 Date of Experiment 2009/4/1 – 2010/3/31 (10 days)

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.

Various kinds of industrial superconducting composites were used.

1. YBCO tape (4mm width) with the total thickness of about 100μm and only 1μm thick YBCO layer
2. Nb_3Sn strands
3. ITER Cable-In-Conduit Conductor (CICC) with the superconducting constituent of Nb_3Sn filament

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.

1. Two YBCO tapes were superposed and were set at the loading machine in such a way that the loading axis was in the scattering plane and to be 45 degree to the incident beam direction. TAKUMI had only 1 detector module for each 90 degree scattering bank, and the beam power was 20kW, during the experiments. Diffraction profiles were collected for 7.2ks.
2. We have measured internal strains of the CuNb/(Nb, Ti)3Sn wires along loading and transverse directions under tensile loads up to 900 N. Six wires with 1 mm in diameter were bundles for the experiments.
3. Internal strain measurements of ITER CICC coils may have a high impact since the CICC are in the shape of real use. We have tried to measure diffraction pattern with a gauge volume of 3×2×15 mm3 for the deepest position in CICC for Toroidal Field (TF) coils.

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

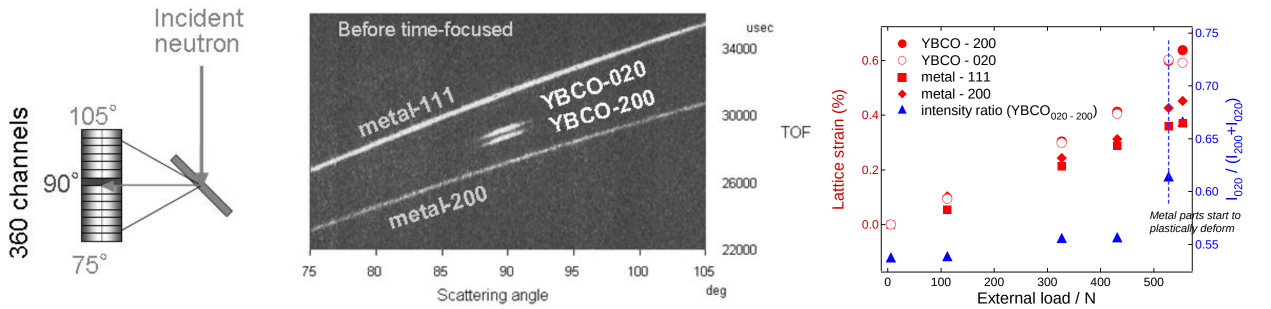

Fig. 1 (left) Schematic geometry of YBCO tape setting for neutron diffraction measurement during tensile deformation, and 2-D diffraction pattern of YBCO tape at the north 90 degree scattering bank; (right) Lattice strain and the integrated peak intensity ratio of YBCO-020 and YBCO-200 with respect to external load

1. Fig. 1(left): The 2-D diffraction pattern was collected at the north 90 degree scattering bank, i.e., data for grains oriented along tensile direction. It was obviously seen that peaks from YBCO phase (020 and 200 peaks) were identified at only around 2θ of 90 degree, showing a very strong texture. The data were then re-binned and time-focused again for a 2θ range of 87.5 to 92.5 degrees, to get diffraction patterns having enough statistics to analyze. The analyzed data is shown in Fig. 1(right). YBCO grains deforms elastically with respect to the external load, as far as the metal parts deforms elastically, and start to plastically deform when the metal parts deform plastically. This result is surprising, since YBCO is brittle and only has 1μm thick. Moreover, the integrated peak intensity ratio of YBCO-020 and YBCO-200 changes with increasing the external load suggesting that domain switching may occur.

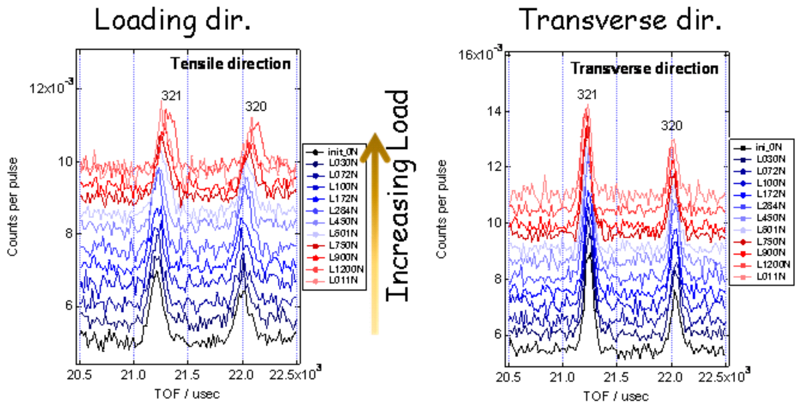

Fig. 2 Enlarged diffraction profiles of Nb3Sn strands during loading at RT

2. Enough intensity of Nb_3Sn peaks was obtained for 30 min statics under the Neutron power of 100kW as shown in Fig. 2. In the loading direction, the tensile strain was obviously observed as a peak shift. Contrary, the opposite shift of the Nb_3Sn peaks was obtained in the transverse directions. From those data, we got the stress-strain properties and relationship of the strains between the loading and transverse directions. Those important results will be used for the analysis about the strain dependence of the superconducting properties for the Nb_3Sn wires by

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

using 3-dimensional strain model.

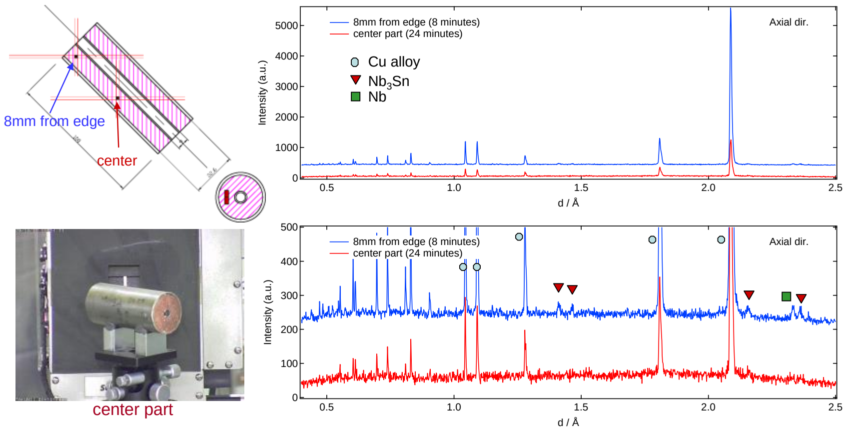

Fig. 3 Diffraction patterns measured for a CICC of TF coil

3. In the diffraction pattern measured at 8mm deep from the edge, peaks from Cu, Nb_3Sn and Nb can be identified, and the peaks can be analyzed quantitatively by increasing statistics. However, in the diffraction pattern at the center part, peaks from Cu alloys could be identified but the diffraction peaks from Nb_3Sn or Nb were difficult to identify. It may be due to a very long path needed to get in and to get away from the position. We believe that we can measure diffraction patterns having peaks from all phases by using a geometry shown in Fig.3.