MLF Experimental Report	提出日 Date of Report July 31, 2017
課題番号 Project No. 2017A0214 実験課題名 Title of experiment Through-thickness distribution of residual stresses in a part produced by additive manufacturing 実験責任者名 Name of principal investigator NANAMI, Norimichi 所属 Affiliation Nihon University	装置責任者 Name of responsible person Stefanus Harjo 装置名 Name of Instrument/（BL No.） TAKUMI/ BL 19 実施日 Date of Experiment May 28-30, 2017

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.

[Name of sample]

An additive manufacturing sample of aluminum AiSi10Mg

[Material composition]

Al (balance), Si (9.0 - 11.0 wt%), Fe (≤ 0.55 wt%), Cu (≤ 0.05 wt%), Mn (≤ 0.45 wt%), Mg (0.2 - 0.45 wt%), Ni (≤ 0.05 wt%), Zn (≤ 0.10 wt%), Pb (≤ 0.05 wt%), Sn (≤. 0.05 wt%), Ti (≤ 0.15 wt%)

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 residual stress measurements of the additive manufacturing (AM) sample that had 20 mm in diameter and 10 mm in height were conducted with the engineering materials diffractometer (BL19 TAKUMI). The particular environmental conditions were not applied for measurements (i.e., at room temperature and under atmospheric pressure). The measurement locations of the AM sample are presented in Figure 1. Seven locations in the in-plane direction and three locations in the through-thickness direction were chosen, totaling to 21 locations in the AM sample. The gage volume of the measurements was 1.5 mm x 1.5 mm x 1 mm. It should be noted that two measurements be conducted at the location, the distances of 8, 9, 10 mm measured from the center of the AM center due to the size of the gage volume. For the axial residual stress measurements, the sample was rotated about the hoop-axis at 90° using the Eurelian cradle, and it was irradiated with neutron beams. Neutron diffraction patterns were measured using a time-of-flight method, and the crystal structure analysis of the obtained experimental data was performed on the software, Z-Rietveld, developed by the High Energy Accelerator Research Organization. Lattice strains per measurement location were calculated, and the three-dimensional residual stress field of the sample was found. It should be noted that the unstressed lattice

spacing be determined by measuring the lattice spacing of the sample where eight 1.5 mm cubes taken from an AM sample were randomly arranged.

The normalized radial, hoop, and axial residual stress distributions in the vicinity of the top face of the AM sample are presented in Figures 2-4, respectively. Note that the normalized stress is defined as a stress on a location over the maximum compressive stress. It was presented that the stress fields at all measurement locations were in compression. The maximum radial and hoop stresses were 2.4 times and 1.5 times as high as the maximum axial stress, respectively. It is seen in Figure 3 that the maximum and minimum values of the radial stresses respectively occur at the distances of 10 mm and 5 mm from the center of the sample. Figure 4 shows that the highest hoop stress is presented in the vicinity of the side of the AM sample while the smallest stress is at the distance of 7 mm measured from the center of the sample. It is observed in Figure 5 that the axial stress decreases as moving away from the center of the sample. In typical casting alloys, the outer region of a part is in compression while the inner region of a part is in tension. Since the local region of the sample was melted and solidified in a very short time during the AM process, it was obtained that the residual stress distribution of the AM sample was different to that of a casting part.

Further investigation to understand the three-dimensional map of residual stresses in the AM sample has been being performed. In parallel, hardness tests of the AM samples are being conducted to define the relationship between hardness and residual stress of AM products.

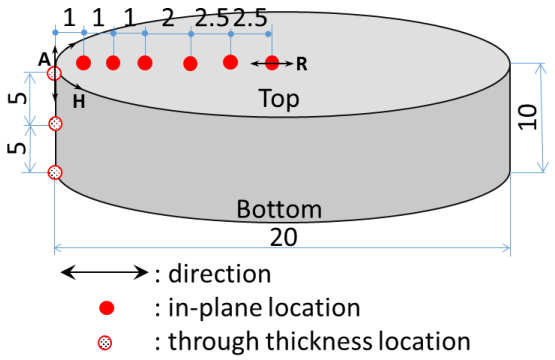

Figure 1. Measurement locations of the AM sample in mm.

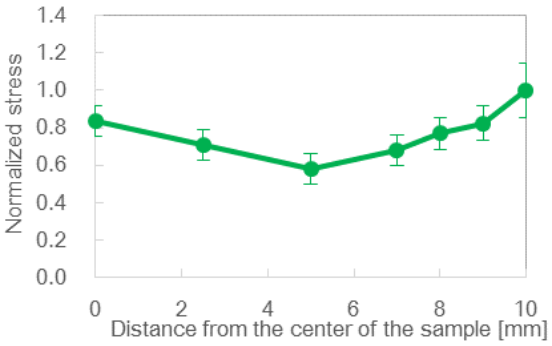

Figure 2. Normalized radial stress distribution on the top.

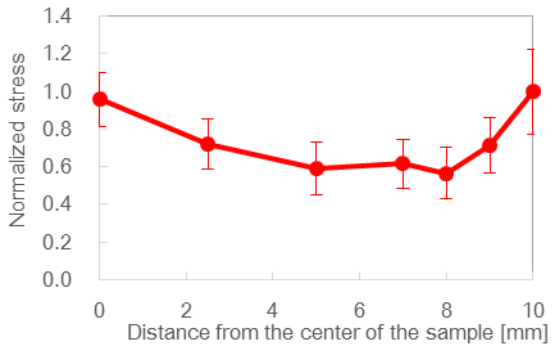

Figure 3. Normalized hoop stress distribution on the top.

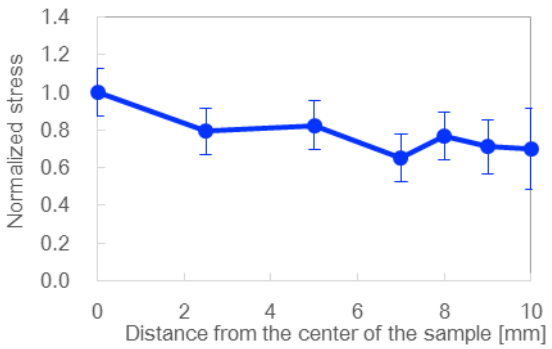

Figure 4. Normalized axial stress distribution on the top.