MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2008A0025 実験課題名 Title of experiment Thermal Stress in Bulk Metallic Glasses and Their Accommodation b y Annealing 実験責任者名 Name of principal investigator Hiroshi Suzuki 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of responsible person Kazuya Aizawa Stefanus Harjo 装置名 Name of Instrument/（BL No.） BL19 実施日 Date of Experiment 22/2/2009-24/2/2009

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.

Specimens: 10vol%ZrC+$Zr_{55}Al_{10}Ni_5Cu_{30}$ bulk metallic glass (BMG, called “composite BMG”)
Monolithic $Zr_{55}Al_{10}Ni_5Cu_{30}$ BMG (called “monolithic BMG”)

Specimen shape: Cylinder with 3mm diameter and 50mm length

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:

Changes in strains in the ZrC phase and the metallic glass phase were measured using neutron diffraction technique under uni-axial loading. Since the ZrC phase has a crystalline structure, Bragg peaks can be observed from this phase. Therefore, lattice strains of the ZrC phase under loading can be measured by observing Bragg peak shift from the initial peak position. It is, however, necessary to analyze the amorphous halo pattern to evaluate phase strains in the metallic glass matrix since Bragg diffraction peaks cannot be observed from an amorphous structure. We have not obtained linear response of the 1^{st} halo peak shift under uni-axial loading in the experiment using RESA diffractometer in JRR-3 guide hall because of a limitation imposed by the incident neutron intensity. In this study, the Q space method, which can evaluate amorphous strains by measuring a peak shift of the 1^{st} halo peak, was utilized in order to confirm a possibility of strain measurement of the metallic glass phase using TOF method. Applied stress on the specimen was varied between 0 MPa and 460 MPa. Deformation behaviors in parallel and perpendicular to loading direction were measured. Incident beam size is 10mm x 10mm.

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

Results:

Figure 1 shows change in strain of the monolithic BMG evaluated by the Q-space method. Linear response was observed until maximum applied stresses in both directions. Therefore, it is confirmed that the strain condition in the metallic glass phase can be measured using the Q-space method in TAKUMI diffractometer. Young's modulus and Poisson ratio of the 1st halo peak is 95 GPa and 0.304, respectively. This Young's modulus is similar to the mechanically measured one of the monolithic BMG which is approximately 101 GPa.

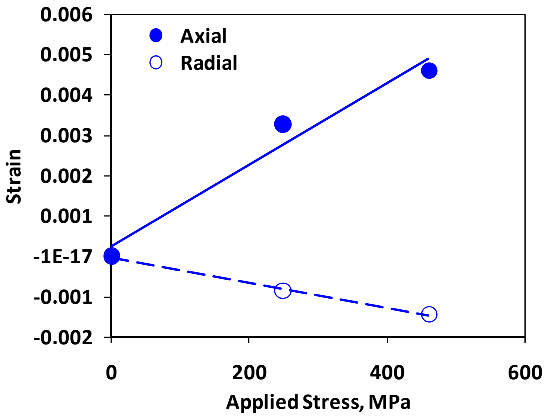

Figure 1: Strain behavior of 1st halo peak of the monolithic BMG measured by TOF method.

Figure 2 shows change in lattice strains of the 220 reflection of the composite BMG. Linear response was observed and Young's modulus and Poisson ration is 198 GPa and 0.249, respectively. Stress-strain relations of the 200 and 420 reflections were also analyzed and these ones indicate linear response to applied stress. Young's modulus and Poisson ratio of each reflections are shown as below,

E_{200}=207 GPa, ν_{200}=0.236,

E_{420}=202 GPa, ν_{420}=0.283.

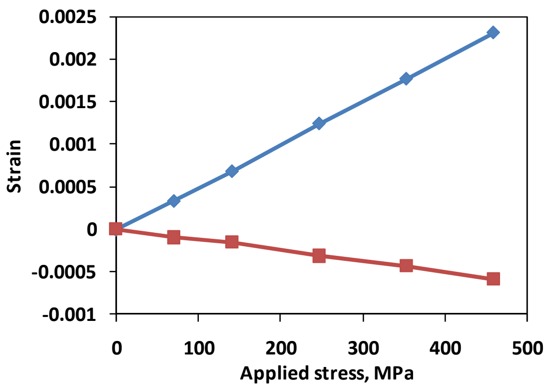

Figure 2: Stress-strain relation of 220 reflection of ZrC phase on the composite BMG.

Figure 3 shows changes in strain of the metallic glass phase of the composite BMG. The result of the monolithic BMG is superimposed on this figure to compare them each other. Radial strain at 250 MPa has been omitted because the data was much scattered. Linear response was observed in both directions and Young's modulus of the 1st halo peak of the BMG composite is 137 GPa which is bigger than that of the monolithic BMG. This means that the ZrC particles would constrain deformation of the composite BMG. Poisson ratio is 0.384 which is also bigger than that of the monolithic BMG.

In this study, it was confirmed that the deformation behaviors of the metallic glass matrix as well as the ZrC particle can be evaluated by measuring the 1st halo peak position using TAKUMI diffractometer. This result will lead to further understanding the deformation mechanism of the ZrC reinforced $Zr_{55}Al_{10}Ni_5Cu_{30}$ BMG.

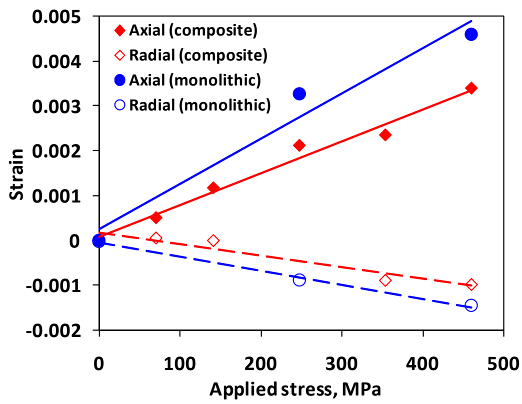

Figure 3: Strain behaviors of 1st halo peak of the composite BMG measured by TOF method.