MLF Experimental Report	提出日 Date of Report
課題番号 Project No. 2009A0036 実験課題名 Title of experiment Thermal Stress in Bulk Metallic Glasses and Their Accommodation by 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 22/10/2009-23/10/2009

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+$Zr_{55}Al_{10}Ni_5Cu_{30}$ BMG (called "composite BMG")

Specimen shape: Cylinder with 3 mm diameter and 6 mm 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.

It has been known that plastic deformation appears in composite BMG because of bond effect of the ZrC particles. However, annealing leads it to brittle and the plastic deformation disappears. In this study, the deformation and fracture mechanisms of annealed composite BMG was discussed by measuring strain changes in the ZrC phase.

As-cast BMG composite specimens were prepared, and a part of them were annealed at 697 K for 2 minutes. These specimens were deformed in the longitudinal direction and five or six specimens with different deformation levels were prepared as shown in Table 1. Strain change of ZrC phase was evaluated by averaging peak shifts of four ZrC diffractions (200, 220, 222, 420) from initial peak positions of non-deformed specimen. Radial collimator was not used and

Table 1 Specimen conditions

As cast

Sample No	Stop stress	Stop strain	Note
1	0	0	As-cast
2	518	0.005215	Deformed elastically
3	937	0.009581	Deformed elastically
4	1403	0.014343	Deformed elastically
5	1936	0.019104	Deformed until around yield-point

Annealed

Sample No	Stop stress	Stop strain	Note
1	0	0	As-cast
2	520	0.003399	Deformed elastically
3	940	0.008614	Deformed elastically
4	1324	0.010885	Deformed elastically
5	1928	0.018141	Deformed until around yield-point
6	2091	0.018489	Deformed until fracture

specimens were set up on the sample table carefully.

Figure 1 shows strain changes in ZrC phase measured using TAKUMI. Different strain change was clearly observed between as-cast and annealed samples. In as-cast BMG specimen, tensile strain was generated around yield point after observing compressive strains in samples-3 and -4. Similar behavior has been observed in previous studies although the compressive strains observed at Samples-3 and 4 should be smaller. On the other hand, tensile strain was generated in the annealed specimen at low stop strain during macroscopic elastic deformation, and no compressive strain was observed before fracture. To verify the results measured using TAKUMI, strains of each specimen were measured again using RESA-1 diffractometer in JRR-3 guide hall. Changes in lattice strain of ZrC(220) are plotted in Fig. 2. Trends of strain changes of both specimens were similar to results measured by TAKUMI shown in Fig. 1 although strains of the annealed specimen were scattered. Furthermore, high compressive strains observed in samples-3 and -4 followed results in Fig. 1 although the mechanism of that has not been explained. Results obtained using TAKUMI shown in Fig. 1 might be rather high accuracy since the strains were determined by multi peak fitting.

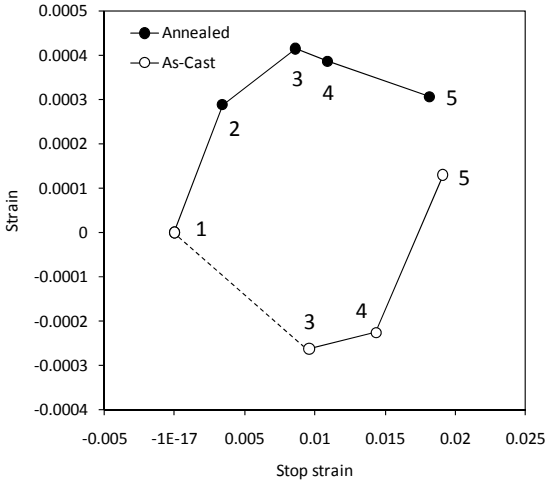

Fig. 1 Strain in loading axis of ZrC phase in deformed BMG composite specimens, measured by TAKUMI.

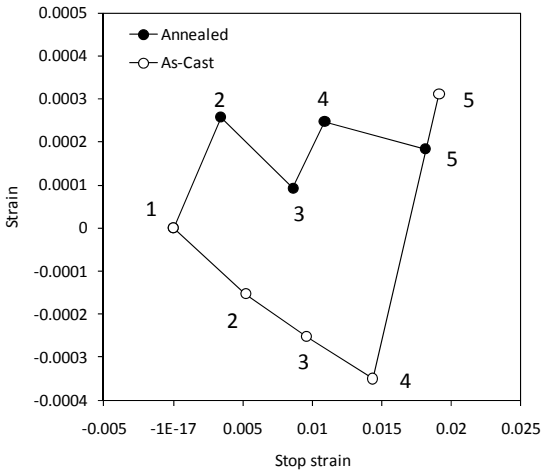

Fig. 2 Strains in loading axis of ZrC phase in deformed BMG composite specimens, measured by RESA-1.

In this study, different strain change was observed between as-cast and annealed specimens, which means that the deformation mechanism of annealed specimen was different from that of as-cast specimen. Metallic glass matrix around ZrC particles was locally yielded at early loading in the annealed specimens.