The University of Osaka
Institutional Knowledge Archive

Title	Shock-assisted joining between metallic glass and ceramics
Author(s)	Atou, Toshiyuki; Mukogawa, Shintaro; Kimura, Hisamichi et al.
Citation	Transactions of JWRI. 2010, 39(2), p. 312-313
Version Type	VoR
URL	https://doi.org/10.18910/24834
rights	
Note	

The University of Osaka Institutional Knowledge Archive : OUKA

https://ir.library.osaka-u.ac.jp/

The University of Osaka

Shock-assisted joining between metallic glass and ceramics†

ATOU Toshiyuki *, MUKOGAWA Shintaro **, KIMURA Hisamichi ***, ITO Shun ***
and KIKUCHI Masae ****

KEY WORDS: (Metallic glass) (Ceramics) (Joining) (Shock wave) (High pressure) (High temperature) (Short duration)

1. Introduction

Metallic glasses have many specific features in mechanical and corrosion resistance. If metallic glasses could be joined with ceramics, the application field could be widely spread by combining the merits of each material, i.e. biomaterials, electronics, and so on. However, formation of well joined interface between a metallic glass and a ceramic is difficult due to the different nature of chemical bonding in these two materials, as well as the metastable state of metallic glasses.

Intense shock waves can generate very high pressure and temperature in a short period of time about 1 μs in condensed matters. Because of the impulsive nature of shock conditions, joining between ceramics and metastable metallic glass might be realized without crystallization of metallic glass. Under such extreme conditions, unusual redox reactions have been reported between metals (Zr, Nb) and ceramic ((SiO_2) under shock compression [1,2]. We have expected that joining between metallic glass and ceramics can be achieved by shock-loading with chemical reactions to enhance the firm joining. As a model case, we tried shock-assisted joining between $Zr_{55}Al_{10}Ni_5Cu_{30}$ metallic glass and quartz (SiO_2) using gun method, and the interface between metallic glass and silica was examined by SEM, TEM, and EPMA measurements.

2. Experimental

Shock-loading experiments were performed using a two-stage light gas gun at Tokyo Institute of Technology up to 2.1 km/s (**Fig. 1**(a)). 3-mm-thick and 21-mm –diameter Cu flyer plates were used. Flyer velocity was measured using a magneto-flyer method, and the pressures in the recovery capsule were determined by an impedance match method [3]. Fig. 1(b) shows a shock recovery system used for recovery experiment. $Zr_{55}Al_{10}Ni_5Cu_{30}$ metallic glass was formed into disk 14-mm in diameter and 1-mm in thickness and then encased in an iron recovery capsule with quartz (SiO_2) powder in 1-mm thick. Porosity of quartz powder was estimated to be about 50 %. The recovery capsule was placed within a steel recovery fixture [4]. Recovered specimens were examined using SEM, TEM, and EPMA measurements to investigate the microstructures in the interface between metallic glass and SiO_2.

3. Results and Discussion

In the sample recovered from 24 GPa, consolidated crystalline SiO_2 (quartz) 50-200 μm in thick was adherent to the surface of metallic glass, as shown in SEM image (**Fig. 2**). Almost all the area of the surface was covered by quartz. Textures in which melted metal seems to flow into the SiO_2 layer were observed, revealing complicated microstructure in the interface. **Figure 3** shows EPMA mapping of the interface. Metallic elements infiltrated into the SiO_2 layer with 20-30 μm in depth, but no apparent deviation from the chemical composition of the metallic glass was observed. Furthermore, microtexture observed by TEM showed metallic glass joined amorphous SiO_2 with only partial crystallization of metallic glass (**Fig. 4**).

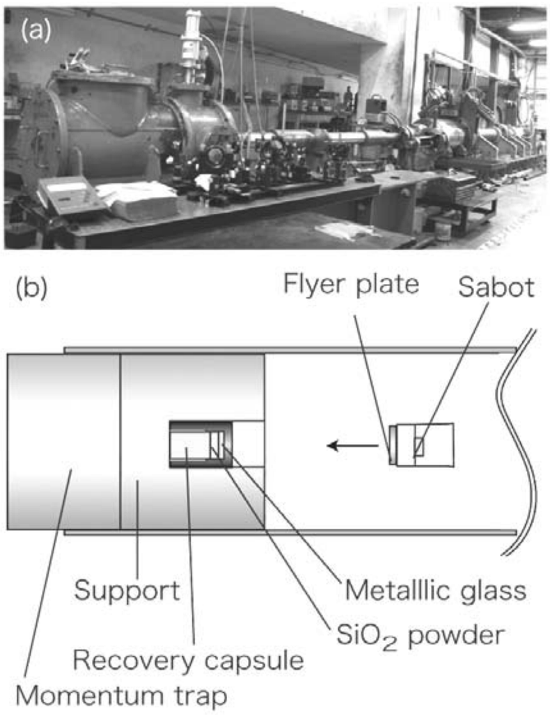

Fig. 1 (a) Two-stage light gas gun installed at Tokyo Tech (b) Shock recovery system used for shock assisted joining experiments (*see text*).

† Received on 30 September 2010
* MSL, Tokyo Tech., Yokohama, Japan
** IGSSE, Tokyo Tech.,, Yokohama, Japan
*** IMR, Tohoku Univ., Sendai, Japan
**** Kansei Center, Tohoku Fukushi Univ., Sendai, Japan

Transactions of JWRI is published by Joining and Welding Research Institute, Osaka University, Ibaraki, Osaka 567-0047, Japan

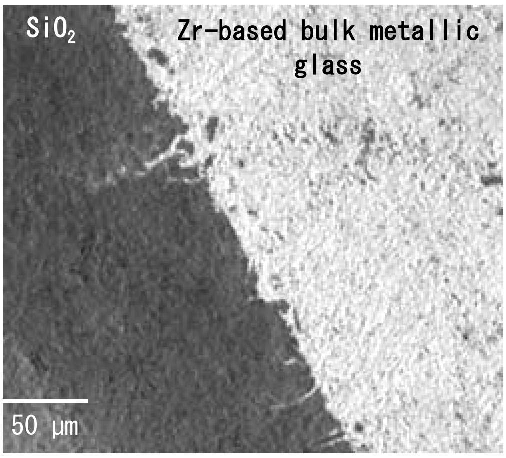

Fig. 2 SEM photograph of interface of metallic glass and SiO_2 shock-loaded to 24 GPa.

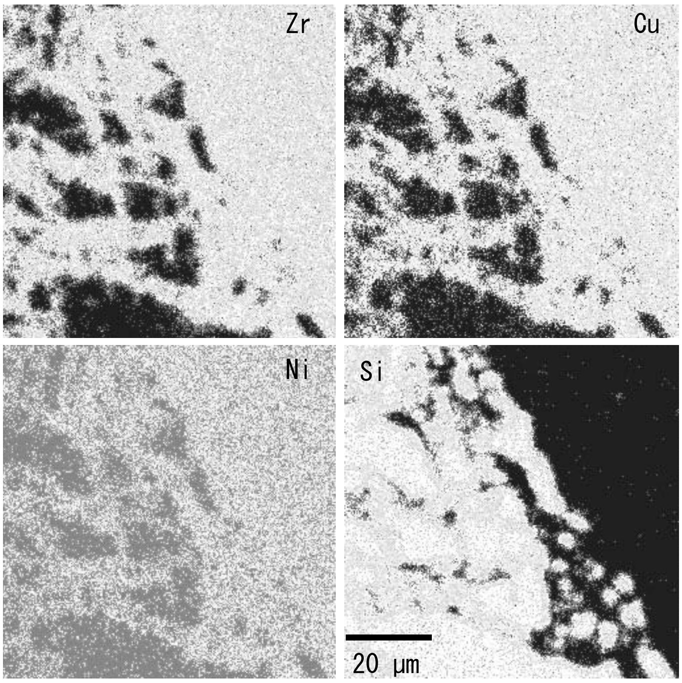

Fig. 3 Mapping by EPMA of interface of glass and SiO_2 shock-loaded to 24 GPa.

These results suggest that the joining of this interface might be due to physical (mechanical) adhesion, as distinct from the chemical reaction between metallic glass and quartz, as observed in the previous shock experiments [1, 2]. On the other hand, recovered sample from 48 GPa showed metallic glass surface covered with transparent SiO_2 amorphous of 30-200 μm thick. This surface of the metallic glass exhibited black color, suggestive of a chemical reaction at the interface. Under higher shock pressure, different adhesion mechanisms with accompanying chemical changes might be occurring. Detailed analysis of the interface is next step of this study.

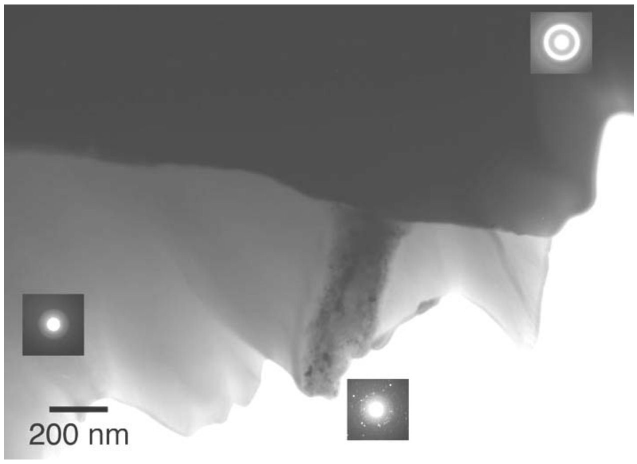

Fig. 4 TEM photograph of interface of metallic glass and amorphous SiO_2 shock-loaded to 28 GPa.

4. Conclusions

The conclusions of this study are summarized as follows.

(1) Joining between metallic glass and ceramic was tried using impulsive shock-loading to $Zr_{55}Al_{10}Ni_5Cu_{30}$ metallic glass and quartz (SiO_2) system.

(2) We have confirmed that metallic glass could be covered with thin layer of SiO_2.

(3) Microtexture observation suggested that adhesion mechanism might be different against applied shock pressure.

References

[1] M. Kikuchi, Y. Syono, K. Fukuoka, K. Hiraga: J. Mat. Sci. Lett., 6 (1987), pp.97-99.

[2] R. Murao, M. Kikuchi, K. Fukuoka, E. Aoyagi, T. Atou, Y. Syono: J. Mat. Res., 14 (1999), pp.3169-3174.

[3] T. Goto, Y. Syono: *Materials science of the Earth's Interior (Ed: I. Sunagawa)*, Terra, Tokyo (1984), pp.605.

[4] T. Hongo, T. Atou, S. Ito, K. Yubuta, M. Kikuchi, K. G. Nakamura, S. Itoh, K. Kusaba, K. Fukuoka, and K. Kondo: Phys. Rev, B76 (2007), pp.104114.