

Recent researches on bulk metallic glasses

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Current topics

- * **Ductility improvement of Bulk metallic glass (BMG)**
- * **Analysis of plastic strain and deformation mode of a Zr-based BMG in compression**
- * **Flow serration and shear band propagation in BMGs**

Strategies for improving ductility

**Extrinsic
toughening**

Micrometer-sized structural heterogeneity

- (a) Micrometer-sized ductile crystalline phase
- (b) Micrometer-sized porosity

Nanometer-sized structural heterogeneity

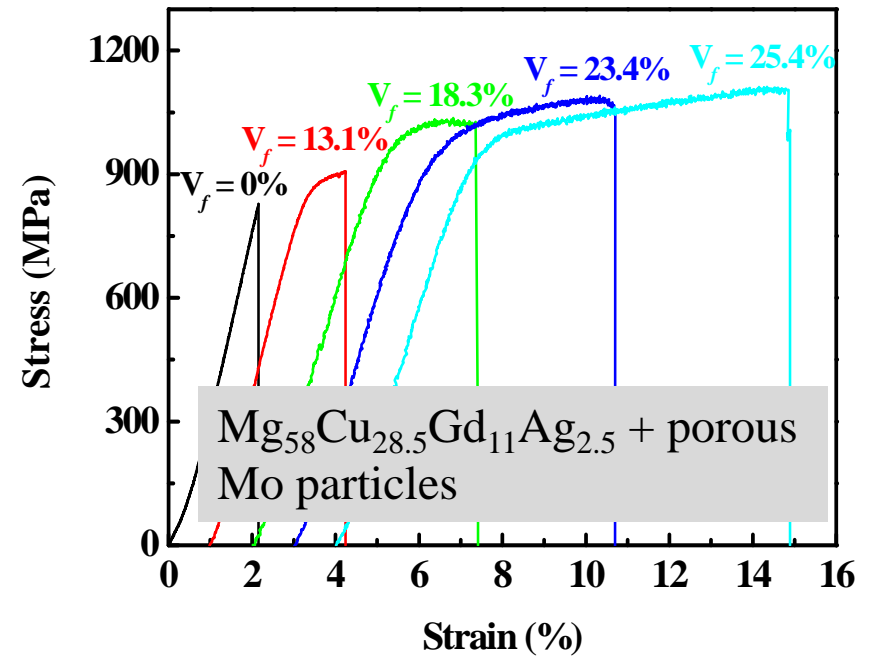
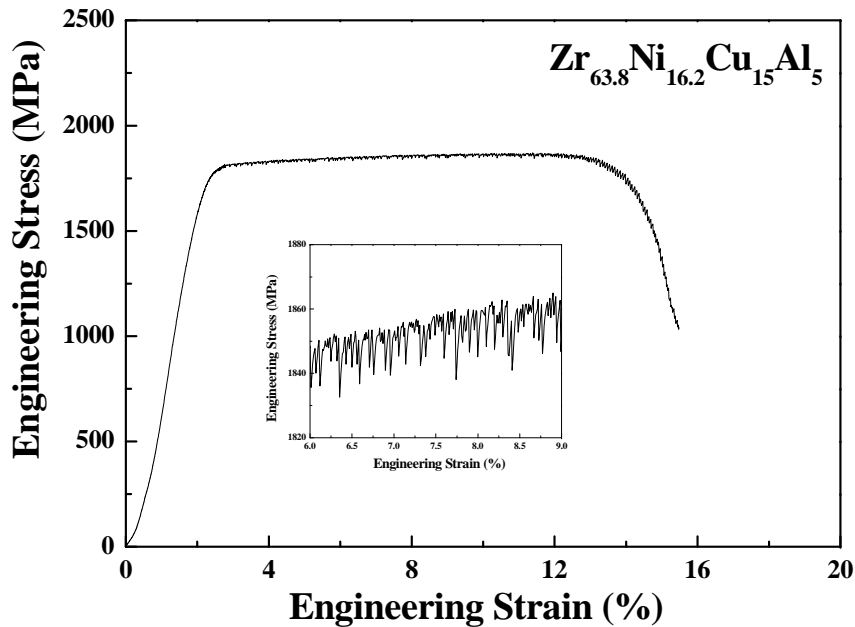
- (a) Nanocrystallization induced before deformation
- (b) Nanocrystallization induced during deformation
- (c) In-situ phase separation (or chemical heterogeneity)

**Intrinsic
toughening**

High Poisson's ratio

Large amount of randomly distributed free volume

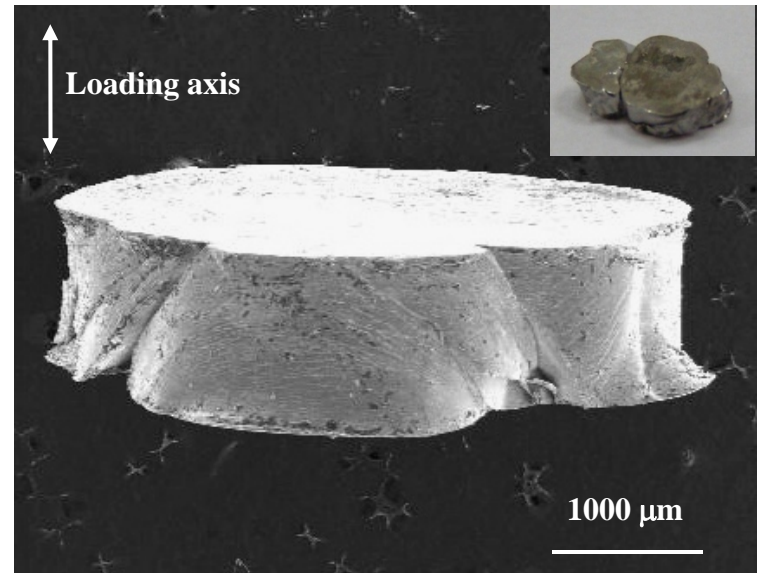
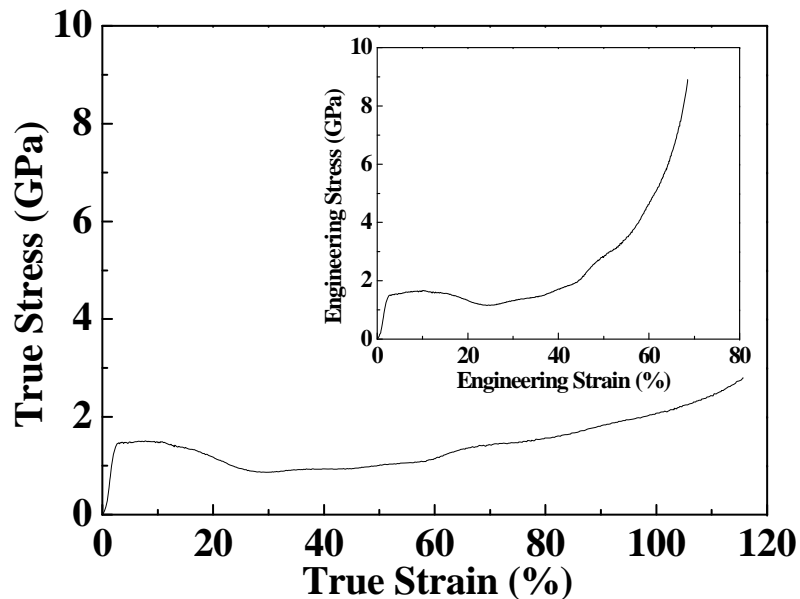
Ductility improvement of BMG



Materials	Ductility	Materials	Ductility
Monolithic Zr-based BMG	~1-3%	Phase-separated Zr-based BMG	~15%
Monolithic Mg-based BMG	0%	Mg-based BMG composite	~8%

Analysis of plastic strain and deformation mode of a Zr-based BMG in compression

$\text{Zr}_{63.8}\text{Ni}_{16.2}\text{Cu}_{15}\text{Al}_5$ BMG



Nominal “superplastic”-like behavior in our phase-separated Zr-based BMG was observed based on the stress-strain curve and deformed sample.

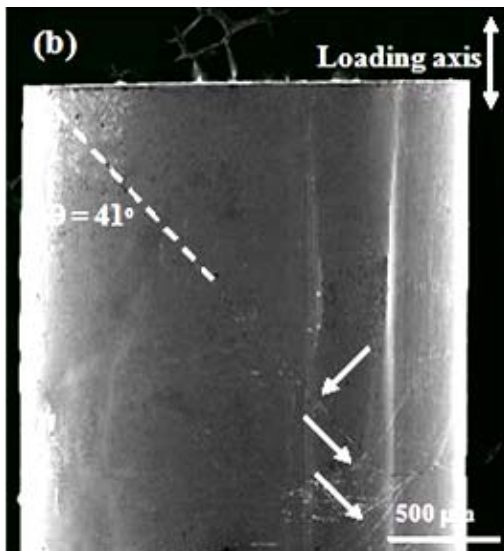
Some questions:

- **Does the work hardening exist?**
- **Is room-temperature compressive “superplasticity” real?**
- **What is the mechanisms?**

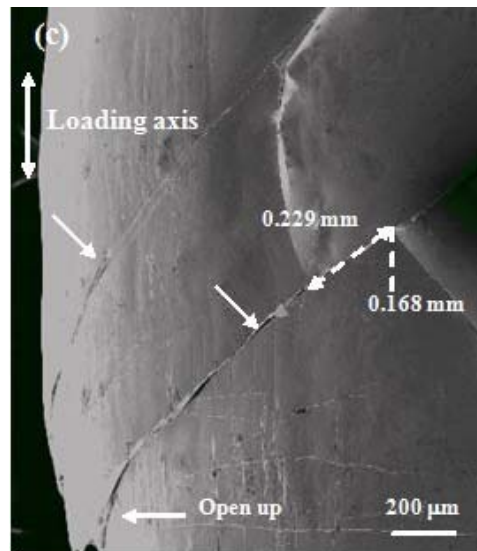
To clarify these questions, samples compressed at various strain stages (3%, 7% and 10%) were examined to trace the entire compression behavior.

Deformation behavior on the 3%-10% strained sample

Nominal strain of 3%



Nominal strain of 7%



Nominal strain of 10%

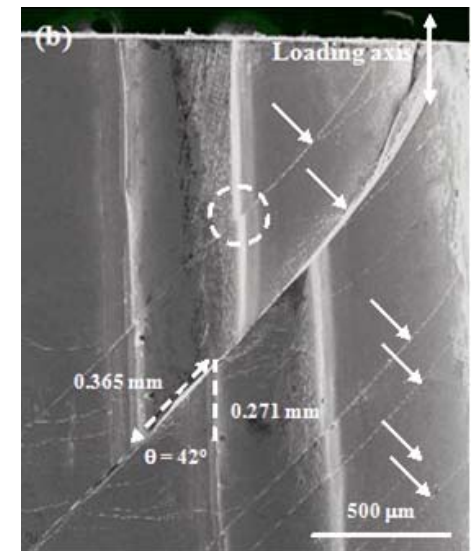
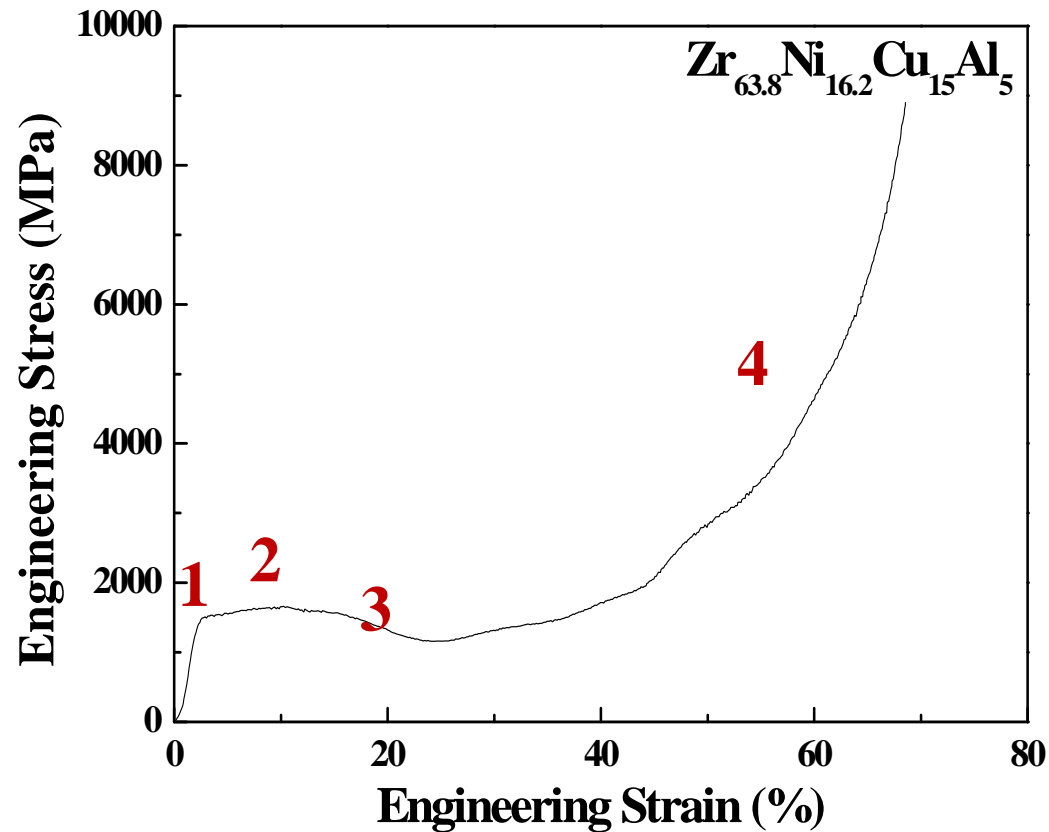


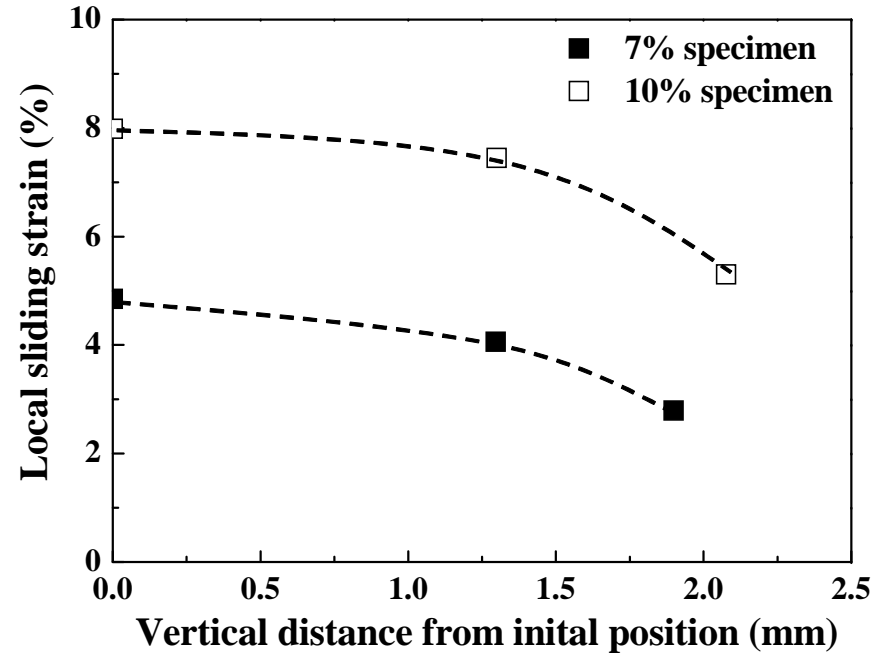
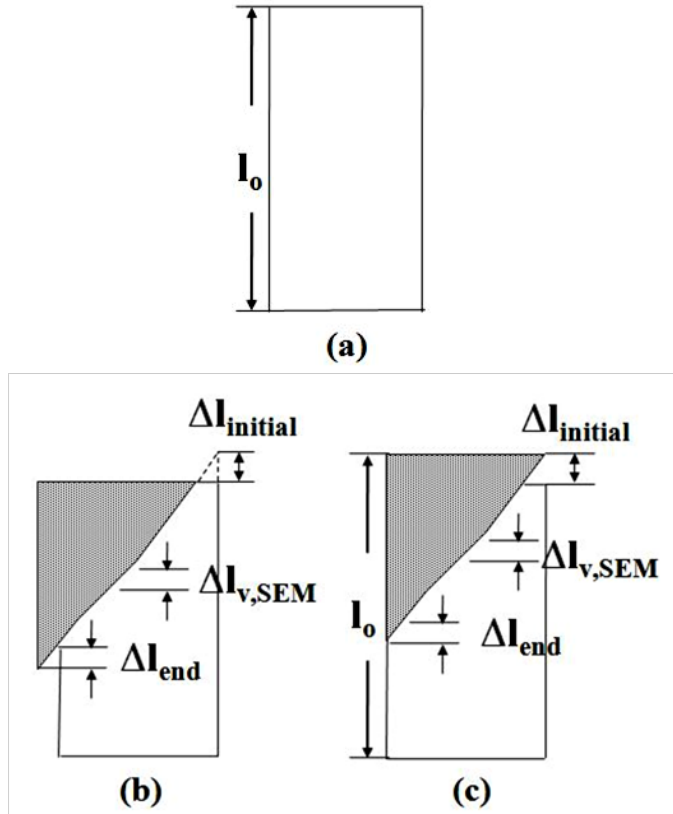
Table 1 Comparison of dimensional changes measured from SEM observations and the load-displacement curves.

Nominal strain	L-D curves		SEM observations		Ratio of sliding
	d_{LD} (mm)	$\epsilon_{p,LD}$	$d_{v,SEM}$ (mm)	$\epsilon_{p,SEM}$	$d_{v,SEM}/d_{LD}$
~3%	0.066	1.6%	---	---	---
~7%	0.238	5.7%	0.168	4.1%	71%
~10%	0.315	8.7%	0.271	7.4%	86%

Zr-based BMG undergoes four stages



Local sliding strain



Local sliding strain decreases with distance from the location where the shear band initiates

Flow serration and shear band propagation in BMGs

- * Shear band dynamics:
 - (1) displacement burst size
 - (2) shear-band propagating speed
 - (3) localized viscosity within propagating shear band
 - (4) shear-band strain
- * Applied strain rate effect on shear band propagation
- * Shear band propagation in different BMGs

References

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2. J. S. C. Jang, J. Y. Chou, T. H. Hung, J. C. Huang, and X. H. Du, *Appl. Phys. Lett.* **92**, 011930 (2008).
3. H. M. Chen, X. H. Du, J. C. Huang, J. S. C. Jang, and T. G. Nieh, *Intermetallics* (2009), To be published.