

Mechanical characteristics of Mg-Cu-Zr thin film metallic glasses

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Motivation

- **To investigate the nano-scale second phase effect on the mechanical properties and shear band deformation mechanism.**
- **To avoid catastrophic fracture of thin film metallic glasses (TFMGs) by using crystalline phase.**

MgCuZr thin films

Mg	$\text{Mg}_{84}\text{Cu}_8\text{Zr}_8$ (Mg84)	$\text{Mg}_{78}\text{Cu}_{12}\text{Zr}_{10}$ (Mg78)	$\text{Mg}_{73}\text{Cu}_{14}\text{Zr}_{13}$ (Mg73)
$\text{Mg}_{55}\text{Cu}_{26}\text{Zr}_{19}$ (Mg55)	$\text{Mg}_{48}\text{Cu}_{28}\text{Zr}_{24}$ (Mg48)	$\text{Mg}_{43}\text{Cu}_{32}\text{Zr}_{25}$ (Mg43)	$\text{Mg}_{39}\text{Cu}_{31}\text{Zr}_{30}$ (Mg39)

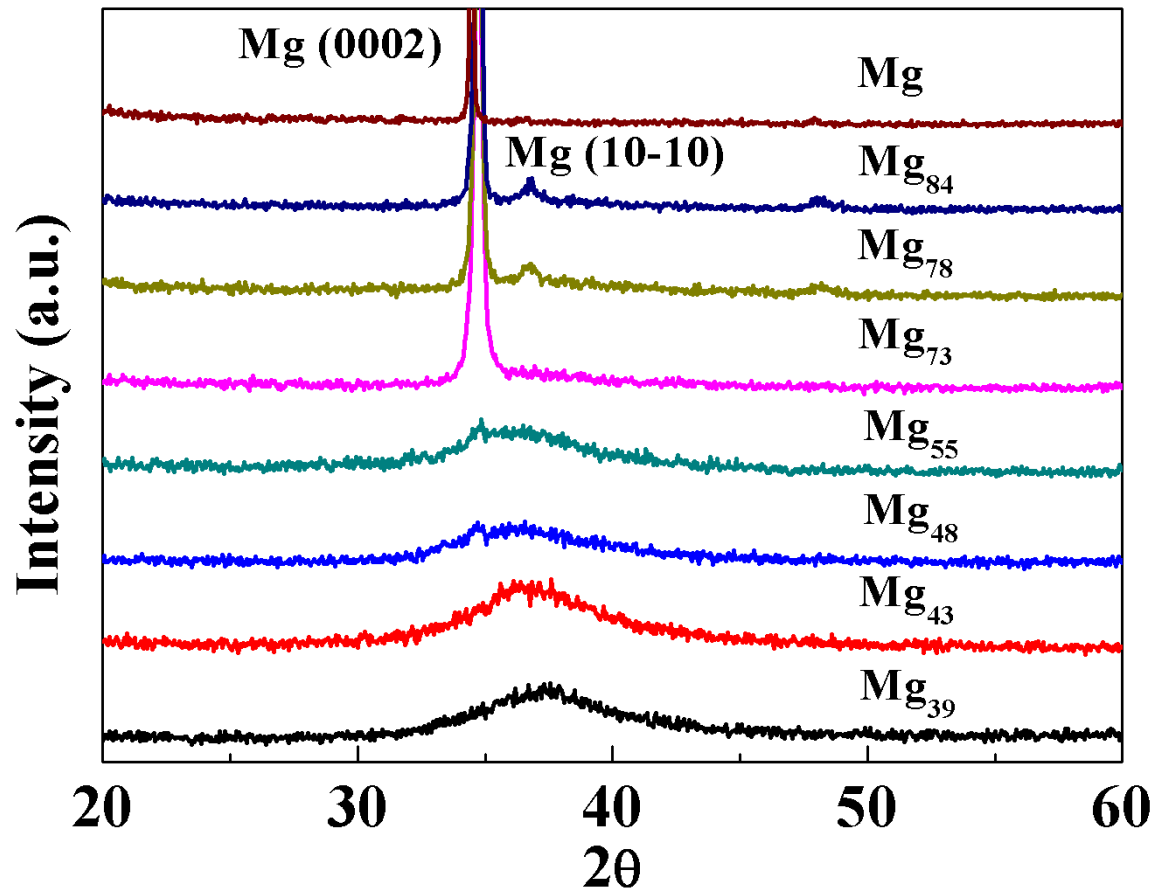
	Mixing enthalpy
Mg-Cu	-3 kJ/mole
Zr-Cu	-23 kJ/mole
Mg-Zr	6 kJ/mole

XRD, modulus and hardness results

	Structure	Modulus (GPa)	Hardness(GPa)
$\text{Mg}_{39}\text{Cu}_{31}\text{Zr}_{30}$	A	91	5.7
$\text{Mg}_{43}\text{Cu}_{32}\text{Zr}_{25}$	A	87	5.4
$\text{Mg}_{48}\text{Cu}_{28}\text{Zr}_{24}$	A+NC	86	5.2
$\text{Mg}_{55}\text{Cu}_{26}\text{Zr}_{19}$	A+NC	89	4.7
$\text{Mg}_{73}\text{Cu}_{14}\text{Zr}_{13}$	A+NC	86	3.7
$\text{Mg}_{78}\text{Cu}_{12}\text{Zr}_{10}$	NC	75	3.4
$\text{Mg}_{84}\text{Cu}_8\text{Zr}_8$	NC	72	3.2
Mg	NC	71	1.5

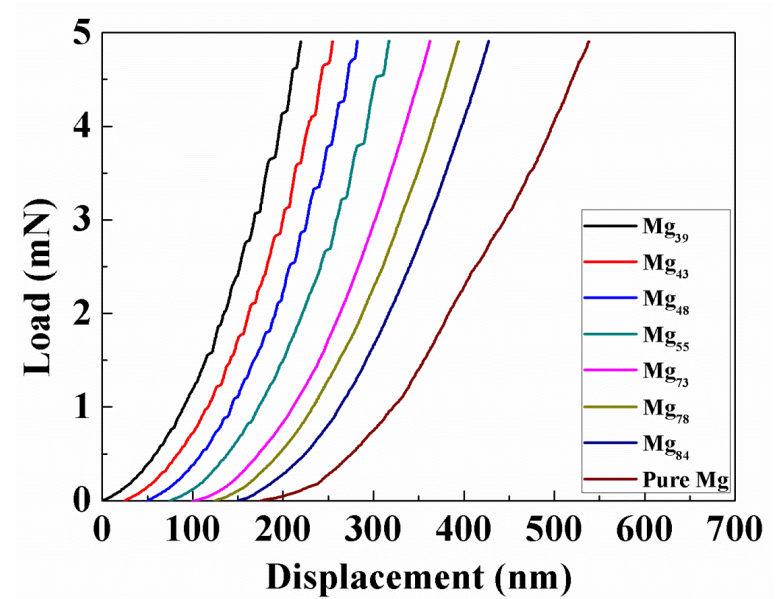
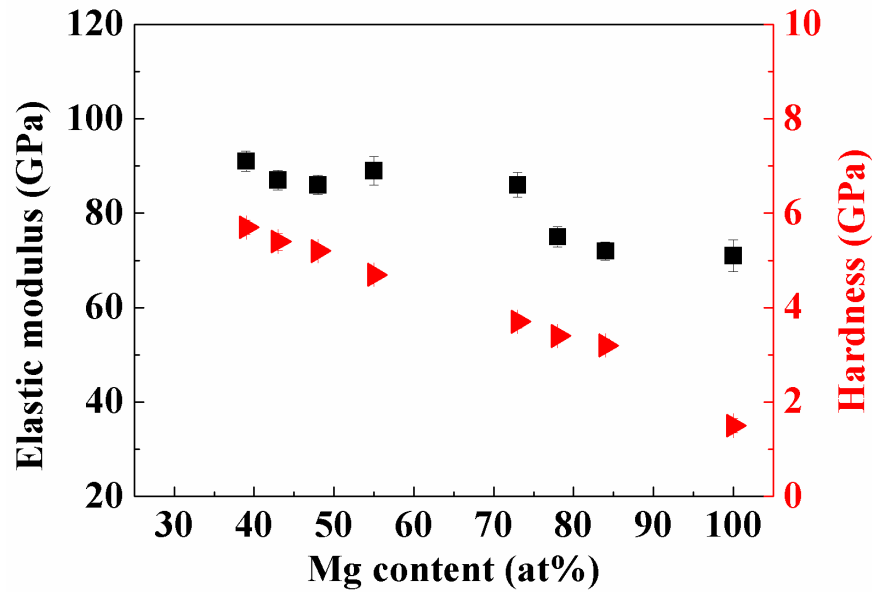
A: amorphous, NC: nanocrytalline

XRD results of MgCuZr thin films

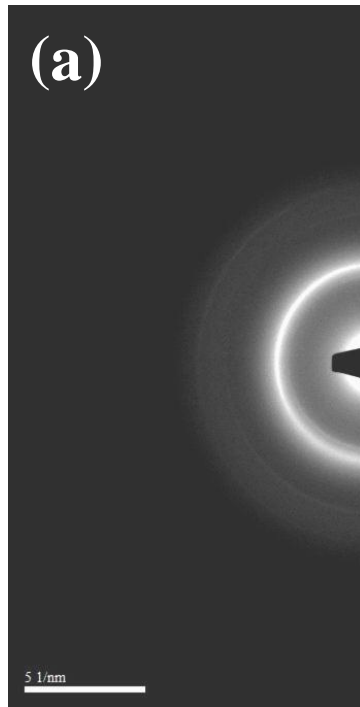


Strong orientation of (0002)

Nanoindentation measurement



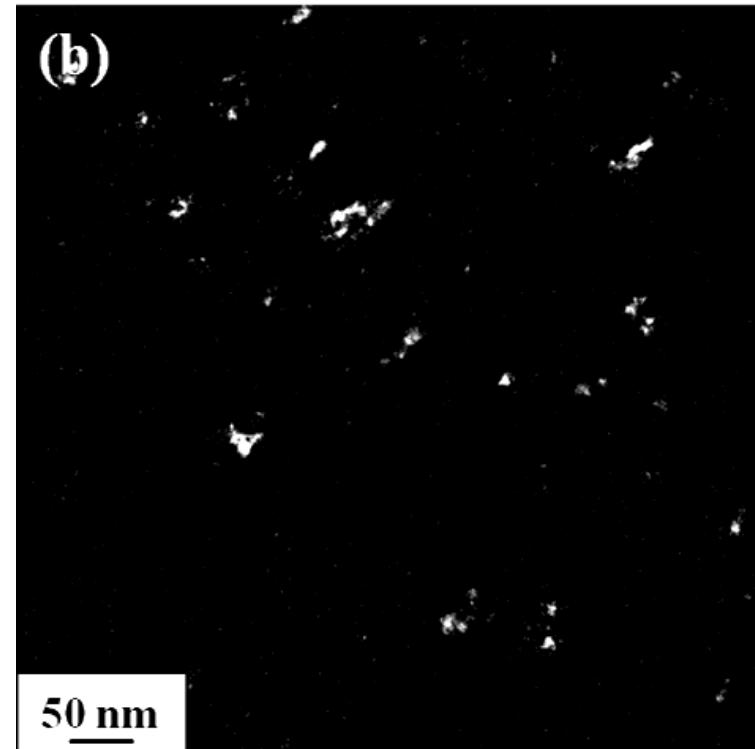
TEM analysis of Mg₅₅



← Mg (01 $\bar{1}$ 2)

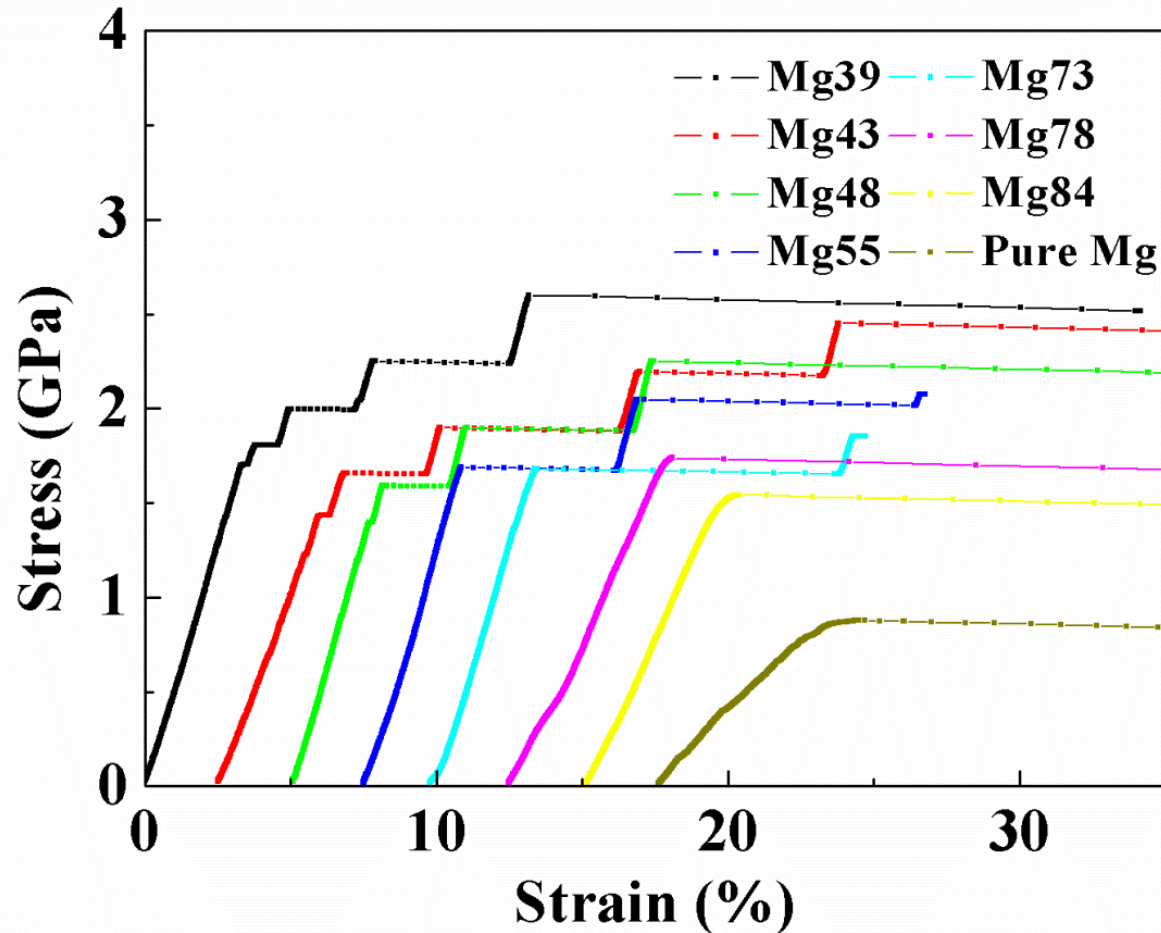
← Mg (0002)

← Mg ($\bar{1}$ 120)

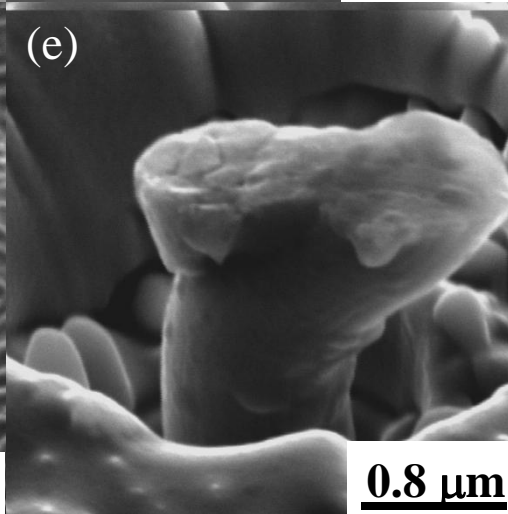
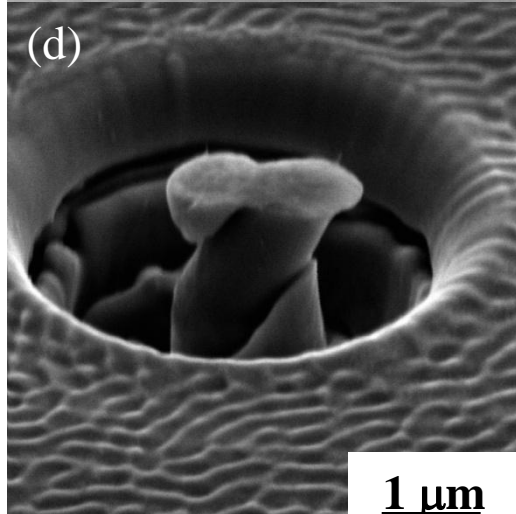
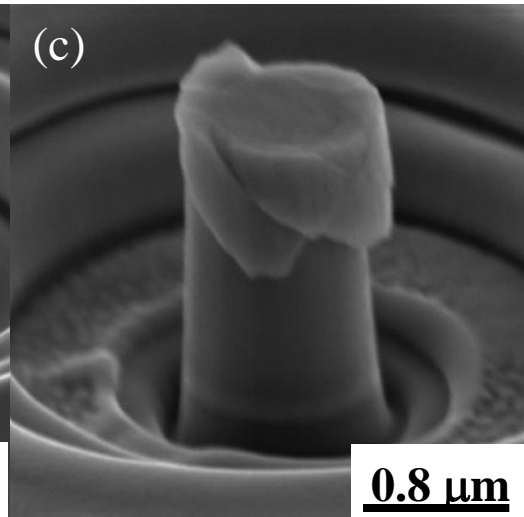
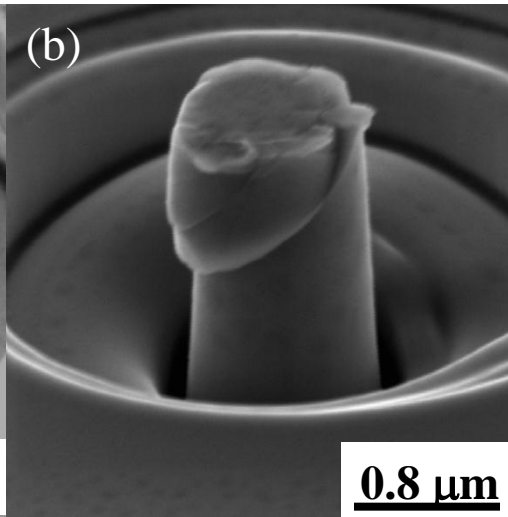
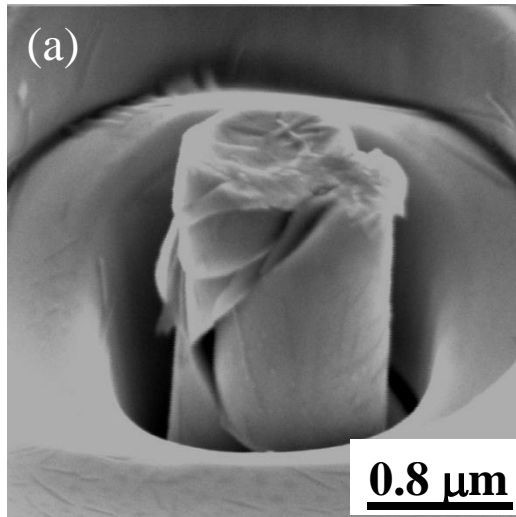


Particles size is about 50 nm

Stress-strain curves of MgCuZr micropillars



SEM images of deformed pillars



- (a) Mg39,
- (b) Mg55,
- (c) Mg73,
- (d) Mg84
- (e) Pure Mg

Summary

MgCuZr thin films with Mg particles were fabricated by sputtering. The orientation of Mg particles is (0002) and the particle size is about 50 nm.

Because c-axis is parallel to the pillar axis and the loading direction, the applied load of compression test is hard to begin dislocation slip system of (0002). Hence, the yield stress of Mg73, Mg78 and Mg84 maintain high yield stress of 1.5 GPa similar to Mg39 thin film.

Due to semi-circular plastic zone the applied stress dose not be parallel to c-axis of nanocrytlline Mg. Hence, the deformation under nanoindentation tests is earlier to start the dislocation slip system of (0002). Therefore, the hardness decreases with increasing Mg content.