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

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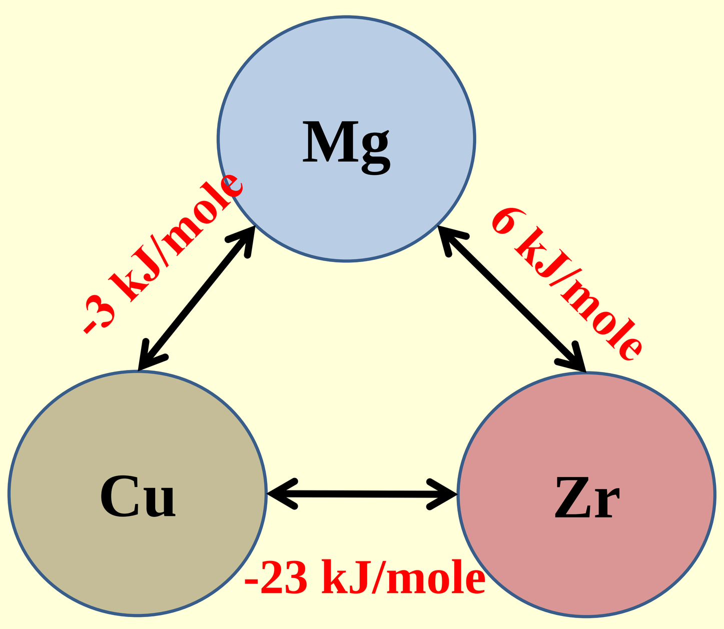
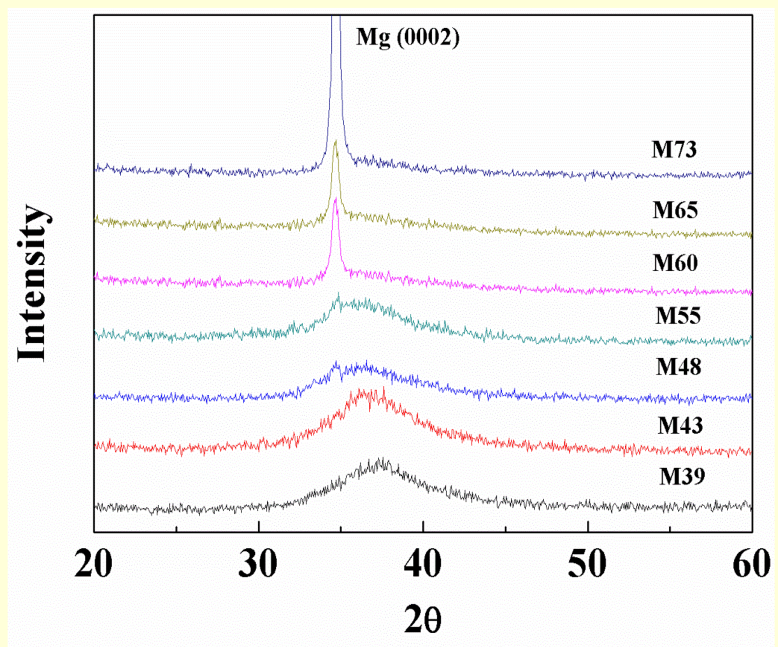
Abstract

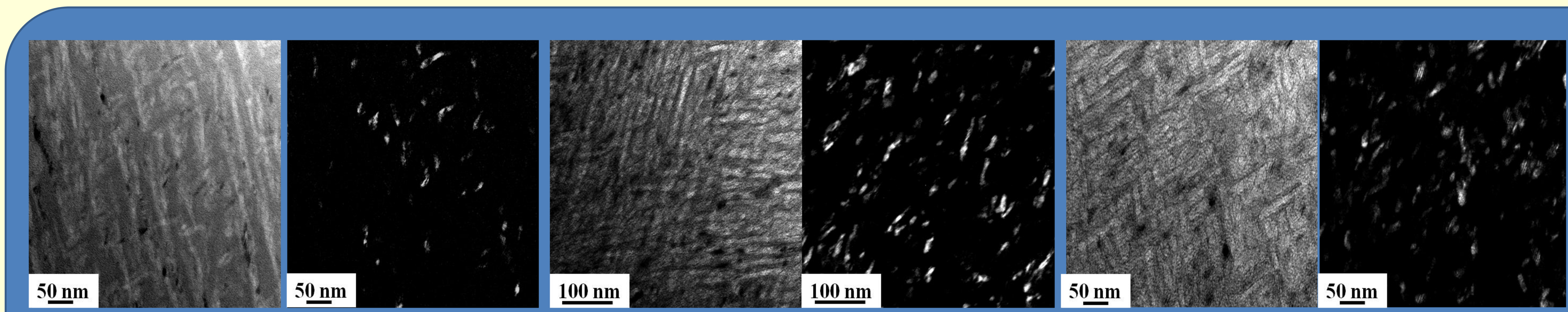
The brittle problem limits the application of thin film metallic glasses (TFMGs) for micro-electromechanical systems (MEMS) devices. For improving the ductility of bulk metallic glasses (BMGs), nanocrystals within the amorphous matrix have been frequently and intentionally added. Similarly, to reduce the brittle problem of TFMGs, the MgCuZr TFMGs, with a positive mixing heat between Mg and Zr, are fabricated via co-sputtering, in an attempt to separate the pure Mg nano-particles from the amorphous ZrCu matrix. The nanocrystalline Mg particles are expected to hinder the propagation of shear bands and to affect the mechanical characteristics of TFMGs. The microstructure and mechanical properties of the sputtered MgCuZr thin films and their FIB-machined micropillars are examined as a function of Mg content from 39 to 100 at%. The Mg content of Mg-based metallic glasses composites is about 48 to 84 at% and Mg particle size in these TGMGs is all about 50 nm, as measured by transmission electron microscopy (TEM).

Results



Mg	$Mg_{84}Cu_{8}Zr_{8}$ (Mg84)	$Mg_{78}Cu_{12}Zr_{10}$ (Mg78)	$Mg_{73}Cu_{14}Zr_{13}$ (Mg73)	$Mg_{65}Cu_{22}Zr_{18}$ (Mg65)
$Mg_{60}Cu_{22}Zr_{18}$ (Mg60)	$Mg_{55}Cu_{26}Zr_{19}$ (Mg55)	$Mg_{48}Cu_{28}Zr_{24}$ (Mg48)	$Mg_{43}Cu_{32}Zr_{25}$ (Mg43)	$Mg_{39}Cu_{31}Zr_{30}$ (Mg39)

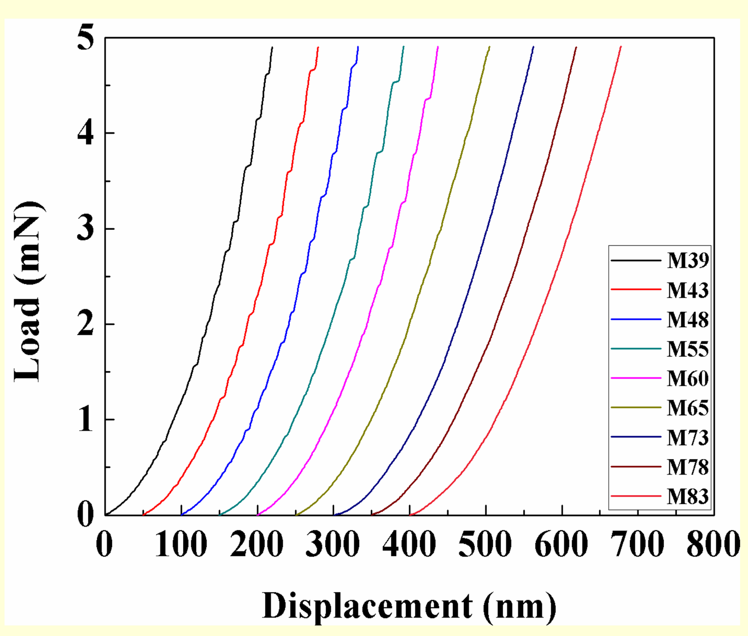


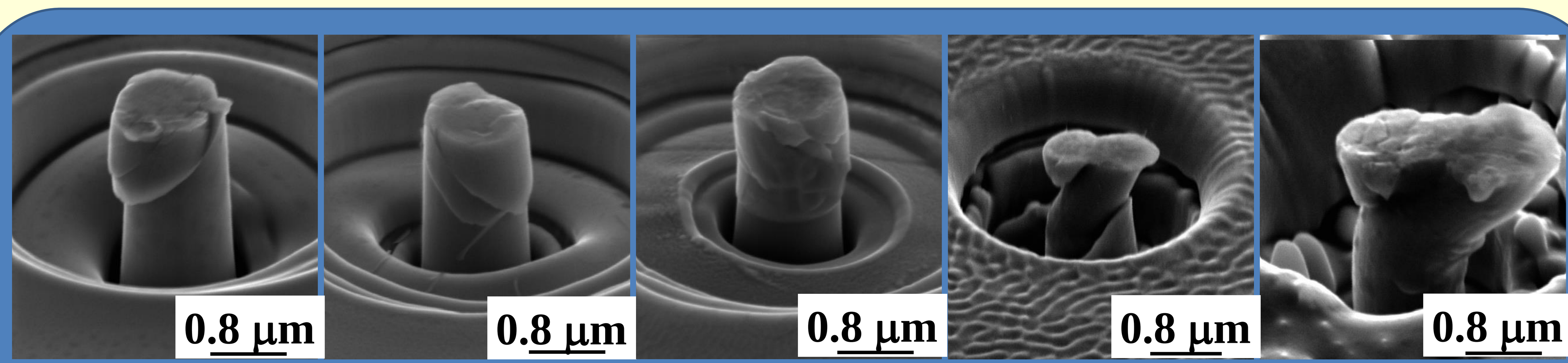


Mg55 **Mg60** **Mg65**

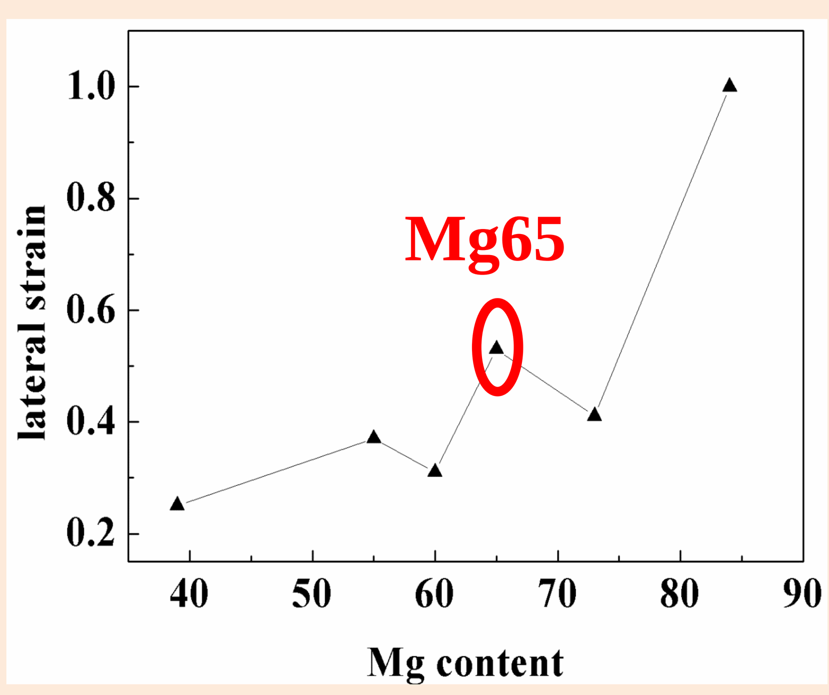
Volume fraction

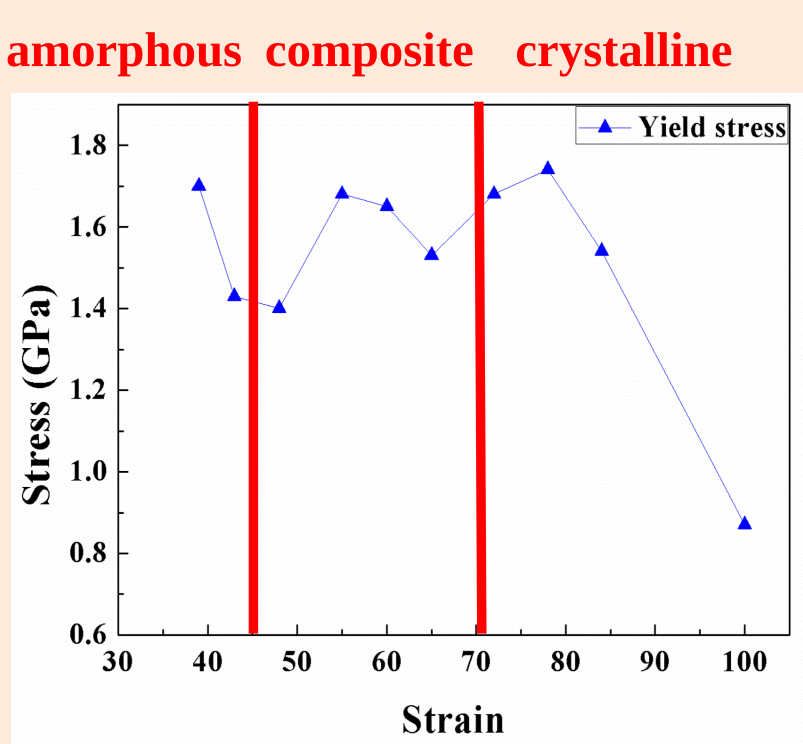
Mg55: <1%
Mg60:2.5 %
Mg65: 3.5%





Mg55 Mg60 Mg65 Mg84 Mg





Conclusions

1. Mg particles were separated out when the composition of Mg lies within 48 at% to 65 at%.

2. The pop-in events under nanoindentation were reduced, suggesting more homogeneous deformation behavior, due to the occurrence of pure Mg particles.

3. The ductility and yield strength of micro-pillars, FIB-machined from MgCuZr thin films, were improved by the separated pure Mg particles.