# Mechanical characteristics of Ag-ZrCu thin film metallic glasses

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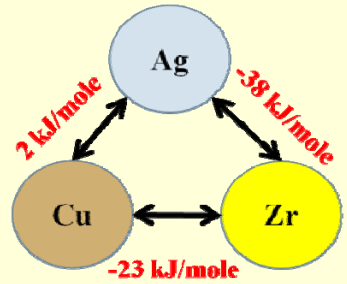
## Abstract

**According to previous work of Mg-ZrCu thin film metallic glasses (TFMGs), the Ag-ZrCu TFMGs are expected to improve the ductility of metallic glasses in the composite form as the BMGC. The Ag-ZrCu thin films are deposited via co-sputtering, in an attempt to separate pure Ag nano-particles. These Ag particles are FCC structure which could be more deformable than pure Mg particles that are HCP structure.**

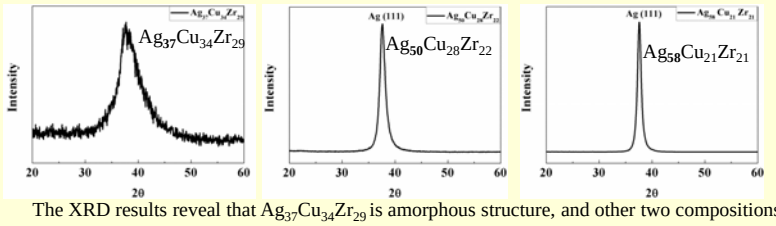
**The mechanical properties of FIB-machined Ag-ZrCu micropillars are examined by nanoindentation. From the nanoindentation and micropillars load-displacement curve, the pop-events are reduced with increasing Ag content and the SEM image also shows no obvious shear bands in higher Ag content pillars.**

**To make sure it's deformation mechanism, the larger load was applied to make pillar be broken. The deformed pillar has large lateral strain similar to Mg-ZrCu thin film systems. It displays that Ag-ZrCu is high potential system for TFMGs.**

## Results




According to heat of mixing between Ag, Zr, Cu, these three elements have potential to form metallic glasses.

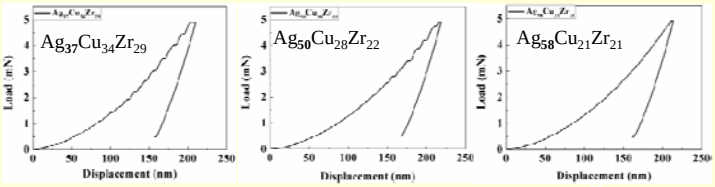



The XRD results reveal that $Ag_{37}Cu_{34}Zr_{29}$ is amorphous structure, and other two compositions have silver precipitates in amorphous matrix.

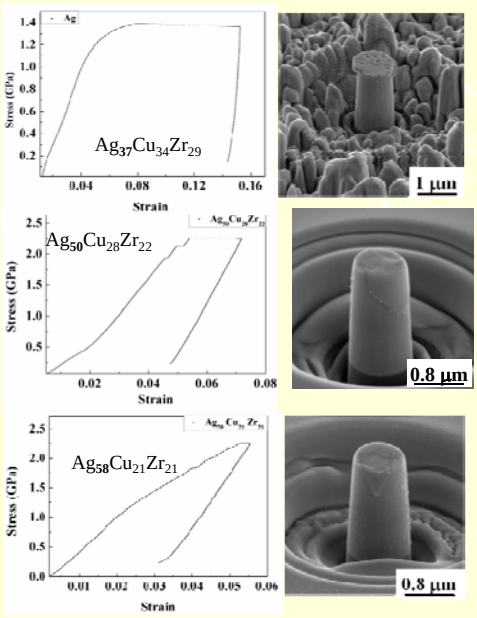
### Nanoindention

| | $Ag_{37}Cu_{34}Zr_{29}$ | $Ag_{50}Cu_{28}Zr_{22}$ | $Ag_{58}Cu_{21}Zr_{21}$ | Ag |
|---|---|---|---|---|
| **Modulus** | 111 GPa | 113 GPa | 120 GPa | 119 GPa |
| **Hardness** | 6.7 GPa | 6.1 GPa | 6.0 GPa | 2.1 GPa |

### Pop-in events




The pop-in events decreasing with the increasing of silver content. This result shows that the ductility is improved because Ag particles were separated out.




The stress-strain curves of $Ag_{37}Cu_{34}Zr_{29}$ (Top), $Ag_{50}Cu_{28}Zr_{22}$ (Middle), and $Ag_{58}Cu_{21}Zr_{21}$ (Bottom).

## Conclusions

**1. Ag particles were separated out when the composition of Ag lies within 40 at% to 60 at%.**

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

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