NANOPARTICLE STABILIZED THIN FILM METALLIC GLASSES

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Due to their amorphous internal structure, metallic glasses have exceptionally high strengths. Within their widespread application, they are limited by two main inherent properties: their inhomogeneous and sudden plastic deformation leading to catastrophic failure, and their structural decay at much lower temperatures than their crystalline counterparts. It is well established that the ductility and strength of bulk metallic glasses can be improved with the addition of a small volume fraction of a crystalline phase, but the synthesis of such composite systems in thin films is much harder to achieve.

A novel deposition system combining a classic physical vapor deposition magnetron and a gas aggregation nanoparticle source enabled the study model systems of thin film metallic glasses with varying contents of nanoparticles. The matrix of $Zr_{50}Cu_{45}Ag_5$ metallic glass was sputtered from a crystalline target, and the single crystal 5 nm W particles were synthesized using a gas aggregation nanoparticle source.

At room temperature, 0.01 vol% W nanoparticle concentration caused a 13% increase in the nanoindentation hardness of the thin film metallic glass. Even more remarkably, the nanoparticles suppressed the crystallization of the films. While at 450 °C a control film containing no nanoparticles experienced significant segregation and subsequent crystallization, this effect was repressed almost entirely thanks to only 0.01 vol% nanoparticles. Unobstructed by nanoparticles, at high temperatures zirconium diffuses to the surface of the film, forming a crystalline layer of up to 100 nm. In contrast, when the nanoparticles are present, this layer is kept to below 30 nm. The stabilization of the morphology is also clear from indentation results, while the hardness of the reference sample changes significantly due to the undesired crystallization, the hardness of the composite remains constant.

In summary, using our unique deposition chamber we have synthesized a novel thin film metallic glass composite, and demonstrated a significant improvement in the thermal stability of the mechanical properties up to 450 °C with only 0.01 vol% of W nanoparticles

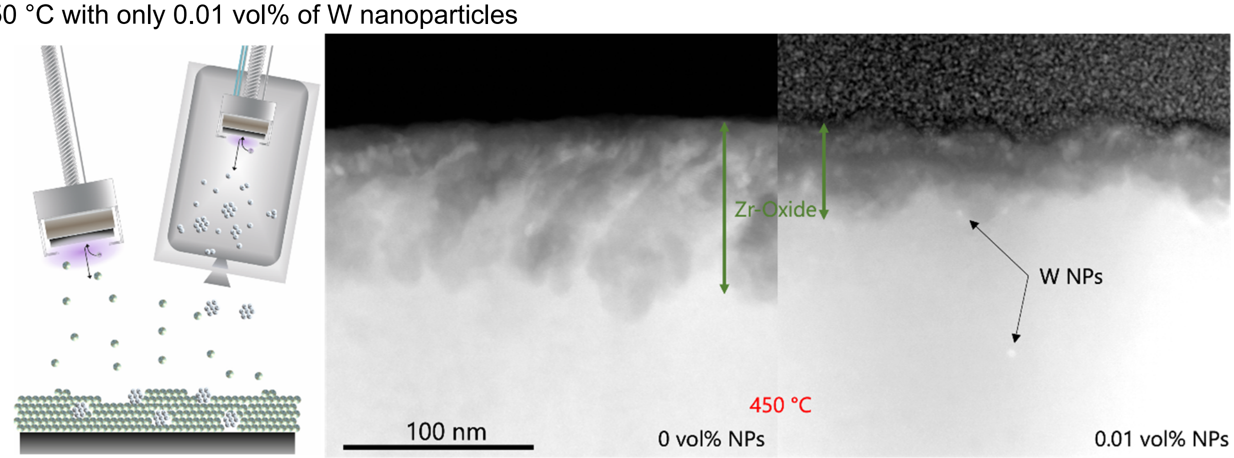

Figure 1 – Left: TEM micrographs of a Zr50Cu45Ag5 TFMG and W nanoparticle composite, Right: Schematic of co-deposition setup