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► To cite this version:

Francesco Bignoli, Andrea Brognara, Philippe Djemia, Damien Faurie, Andrea Li Bassi, et al.. Nanoengineering the glassy state: toward novel thin film metallic glasses with outstanding combination of mechanical properties. C'Nano 2023: The Nanoscience Meeting, Mar 2023, Poitiers, France. hal-04310452

HAL Id: hal-04310452

<https://hal.science/hal-04310452>

Submitted on 27 Nov 2023

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Thematic Session: Nanomechanics

Keywords: Metallic glasses, Thin films, Micro-mechanics.

Disciplinary fields involved: Materials science, Physics, Engineering.

Nanoengineering the glassy state: toward novel thin film metallic glasses with outstanding combination of mechanical properties

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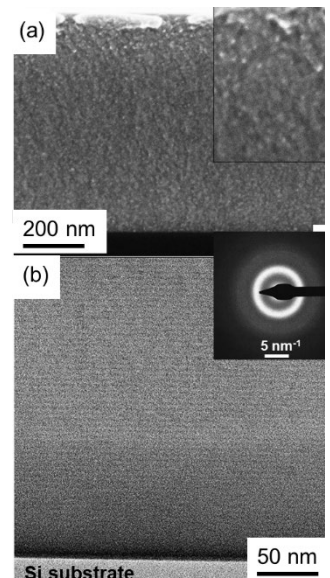
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Thin film metallic glasses (TFMGs) are emerging materials characterized by a unique combination of mechanical involving large yield strength (~ 3 GPa) and large ductility ($>10\%$) [1]. Nevertheless, the synthesis of advanced TFMGs with engineered microstructure and the understanding of their mechanical properties are barely tackled. Here, I will present recent results involving two (2) strategies to develop nanoengineered TFMGs with a controlled microstructure down to the atomic scale, resulting in outstanding and tunable mechanical properties.

Firstly, I will show the potential of Pulsed Laser Deposition (PLD) as a novel technique to synthesize nanostructured $Zr_{50}Cu_{50}$ (%at.) TFMGs. I will show how the control of PLD process parameters enables to synthesize a variety of film microstructures, e.g. compact fully amorphous and amorphous nanogranular, showing large free volume (Fig. a) [2]. This results in unique mechanical behavior as shown by *in situ* TEM/SEM tensile/compression tests, reporting homogeneous deformation for nanogranular TFMGs combined with large yield strength (>3 GPa) and ductility ($>9\%$) [2].

In the second case, I will focus on the fabrication of multilayers with nanoscale period alternating either fully amorphous or amorphous/crystalline sublayers (Fig. b). I will show how the control of the sublayer thickness influences the deformation behavior affecting shear bands formation and tuning the mechanical properties. As an example, alternating CrCoNi (crystalline)/TiZrNbHf (amorphous) nanolayers results in an ultrahigh compressive yield strength (3.6 GPa) and large homogeneous deformation ($\sim 15\%$) [3].



References:

- [1] M. Ghidelli *et al.* Acta Mater., 131, 246, 2017.
- [2] M. Ghidelli *et al.* Acta Mater., 213, 116955, 2021.
- [3] G. Wu *et al.*, Materials Today, 51, 6, 2021.