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Specific features of thin film metallic glasses and their elastic properties relationship

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The bulk metallic glasses BMGs discovered in 1960, are very promising for structural and other applications. The searches for the mechanisms formation, thermal stability, origins of their ductility/brittleness and relationship between density, elastic/plastic properties, local chemical ordering and glass forming ability (GFA) are the hottest topics in the undergoing research of amorphous alloys. Many simple systems such as binary alloys either BMGs or thin film metallic glasses (TFMGs) are conveniently elaborated since a few ten years. Immiscible TE-TL (early transition-late transition metals) is an important category, which has already a good GFA and is used in combination with many other elements. The tremendous problem of BMGs is how to avoid the precipitation of the immiscible elements in the melts or the supercooled liquid. In case of thin films, via the sputtering, a vapor-to-solid, process, it is possible to avoid the precipitation of the immiscible elements, and an over-saturated amount of these elements could be added into the amorphous-alloy matrix. In this search, a systematic study of the properties of representative TE-TL binary alloys is a good starting point and can be extended to multicomponent alloys such as amorphous high entropy alloys, increasing their complexity. This presentation will recall specific features of amorphous materials compared to crystalline ones, conditions of appearance, and discuss their relationship with their elastic properties. Several examples of TFMGs elaborated in collaboration with different groups either by magnetron sputtering or pulsed laser deposition will be discussed, taking advantage of a unique combination of two complementary non-destructive techniques to measure film's thermomechanical properties. The non-conventional Surface Brillouin light Scattering (SBS) and Picosecond Ultrasonics (PU) are used to accurately measure sound velocities from which Debye temperature (θ_D) and isotropic elastic properties (C_{ij}) are calculated. Other mechanical parameter such as the Pugh's shear modulus over bulk modulus ratio (G/B), the Cauchy pressure ($C_{12} - C_{44}$), the cooperative parameter or Poisson ratio and the fragility index can also be used to infer the plastic behavior of these TFMGs. When possible, the usefulness of theoretical tools such as the molecular dynamics in the study of such disordered materials will be recall.

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