MECHANICAL CHARACTERIZATION OF $Cu_{60}Zr_XTi_{40-X}$ BULK METALLIC GLASSES

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The discovery of improved physical and mechanical properties of amorphous and nanocomposite metallic materials respect to their crystalline counterparts [1], has led to an increasing interest and research activity in the study of these materials during the last two decades. The possibility of tailoring amorphous metallic alloys at cooling rates of 1-100 K/s [2], enables these structurally metastable alloys to be manufactured not only in the form of ribbons but also in the form of bulk materials.

Recent investigations of the authors showed a glass forming ability for $Cu_{60}Zr_xTi_{40-x}$ alloys to be very high [3], leading to considerable research work on this system [4-7]. Moreover, these alloys have good mechanical properties (e.g.: tensile fracture strength is around 2000 MPa), which make them of a great interest from the technological point of view. However, due to the fact that the amorphous structure of the systems is a metastable state, being crystalline phases of a lower energy, all the physical properties will be affected by structural relaxation and/or crystallization.

Bulk samples in the shape of rods of 3 mm diameter were produced by Cu-mold casting. The specimens, both as-cast and after thermal treatment, were structurally characterized and mechanically tested to study the dependence on the amorphous state, degree of thermal relaxation and different crystalline volume fraction on both the microscopic and macroscopic mechanical response. Despite the negligible plasticity observed under macroscopic compression test, separation between elastic and plastic deformation has been investigated in the nano-size range by nanoindentation (Figure 1) at different loading rates. Other effects affecting mechanical properties, such as cooling rate during the casting procedure, have been evaluated by indenting in different position of the cylindrical samples cross-section. The use of different indenter geometry has also been an issue in order to study fragility and tenacity of the samples under nanoindentation tests. The advances provided by the nanomechanical tests in the understanding of the mechanical behaviour of the bulk metallic glasses (BMG) under investigation, are a step forward in the improvement and optimisation of these promising materials for structural applications, since the macroscopic compression tests showed a very good behaviour with, for instance, Young's modulus and fracture strength values of about 112 GPa and 1900 MPa respectively for a $Cu_{60}Zr_{22}Ti_{18}$ alloy.

References:

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Figures:

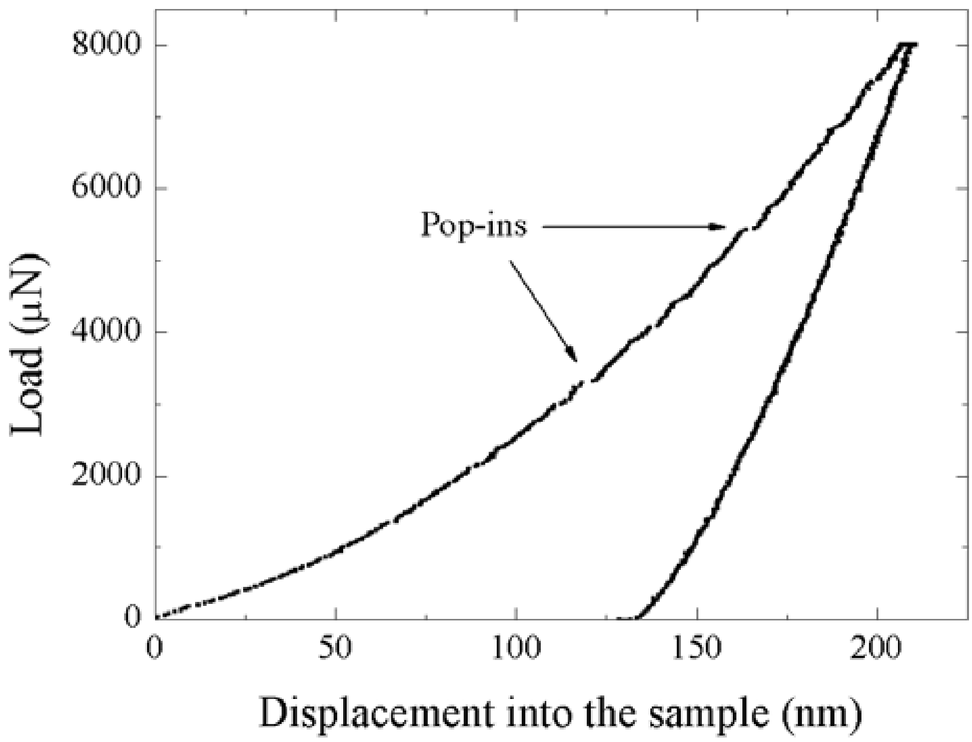

Figure 1. Example of a 12 seconds load-displacement curve on a 3 mm diameter cross-section sample of an as-quenched amorphous $Cu_{60}Zr_{22}Ti_{18}$ alloy showing pop-in events.