MECHANICAL PROPERTIES OF AMORPHOUS AND NANOCRYSTALLINE ALLOYS

P. Rizzi[1], T.Baser[1], G.Fiore[1], R.Piccin[1], M.Satta[1], M. Baricco[1], L.Battezzati[1], P.Matteis[2], G.Mortarino[2], D.Firrao[2]

[1]Dip. Chimica IFM, Centro di Eccellenza NIS, Università di Torino, V. Giuria 9, 10125 Torino, Italy
[2]DISMIC, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129 Torino, ITALY

Metallic materials can be obtained with an amorphous structure if during solidification the nucleation of crystals is avoided. With rapid solidification techniques, such as melt spinning, cooling rates of 10^6 K/s can be reached and glassy alloys can be obtained in form of ribbons of about 30-50 μm thickness. Recently, compositions were found with a high glass forming ability (GFA) that allow the use of lower quenching rates. Some alloys are obtained in an amorphous state by casting them in a copper mold, obtaining ingots of a few millimetres in thickness.
Bulk amorphous alloys show peculiar mechanical properties, such as low modulus of elasticity and high yielding stress. Mechanical properties are also influenced by the presence of crystals embedded in the amorphous matrix. In fact, the movement of shear bands, that governs the plastic deformation of glassy materials, can be contrasted by incorporating a second phase in the alloy, forming composite materials. Shear bands have thickness of the order of a few nanometres and the presence of crystals of similar dimensions influence their nucleation and, therefore, the fracture behaviour of the material. Composite materials can be obtained in different ways: i) by adding second phases to the alloy; in this case, highly stable ceramic particles are often used (e.g. TiC, TiB_2, ZrB_2); ii) crystalline phases produced by the devitrification of the amorphous phase or by casting the alloy from temperatures at which the crystalline phases are not completely molten; iii) crystals can nucleate from the liquid during quenching by using quenching rate lower than the critical cooling rate.
In this work different alloy systems (Fe-based, Mg-based, Pd-based, Au-based, Al-based, Cu-based alloys) are considered and their GFA and mechanical properties are examined. Samples were obtained both by melt-spinning and by copper mold casting and their amorphicity was controlled by x-ray diffraction (XRD). Their devitrification behaviour was studied by calorimetric measurements (DSC), obtaining the glass transition temperature and the crystallisation temperature in order to have information on the interval in which the material is in the undercooling regime.
Vickers microhardness was measured for as quenched samples and at different devitrification stages. On the as quenched ribbons, tensile tests were performed and values of Young modulus and ultimate fracture strength were obtained. From the analysis of fracture surfaces (examined by scanning electron microscopy), information can be obtained on the number of shear bands that nucleate during fracture and, therefore, on the kind of fracture acting in the materials (ductile or brittle). The influence of the size and of the fraction of crystals on the mechanical properties will be outlined.

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