BULK METALLIC GLASSES AND NANOSTRUCTURED MATERIALS

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INTRODUCTION

There is always a requirement for materials having higher performance than the existing one without any extra cost or even paying less. Demands of high performance materials are increasing to improve the efficiency of the products and produce micro-components for various applications. The polycrystalline materials prepared in conventional melting casting route have almost reached to its highest performance level. Hence, newer processing techniques are being adopted to develop newer materials so that the component should have smooth surface finish, minimum shrinkage etc. Excellent fillability and imprintability are prime requirements for the production of good quality micro-precision parts. In this regard, metallic glasses have achieved much attention due to its superior properties compared to the crystalline materials of same composition. The metallic glass can be prepared through rapid solidification technique where liquid metal can be poured on the surface of a rapidly rotating Cu-drum. In this process the cooling rate of the materials become 10^6K/s and the materials are obtained in the form of about 30μm thick ribbon, which is amorphous in nature. The isotropic nature of the material becomes immediate curiosity for functional applications, in particular Fe, Co and Ni based materials for magnetic application. Fig. 1 shows a typical melt-spinning system, which can be used for ribbon preparation. The magnetic property of the materials can be further improved by nanocrystallization.

The high cooling rate required for amorphous structure compelled the development of the materials in the form of ribbon. There have been efforts amongst different research groups to achieve metallic glasses of bigger dimensions in various non-ferrous systems. Chen et al. developed Pd-based bulk metallic glasses (BMGs) with thickness ranging between 0.5mm to 1.0mm and subsequently with higher dimensions for the AuPbSb system. In recent past, various Mg- and Cu- based bulk metallic glasses have been developed using Cu-mould casting. The fundamental requirements for maintaining the glassy structure to obtain bulk metallic glasses

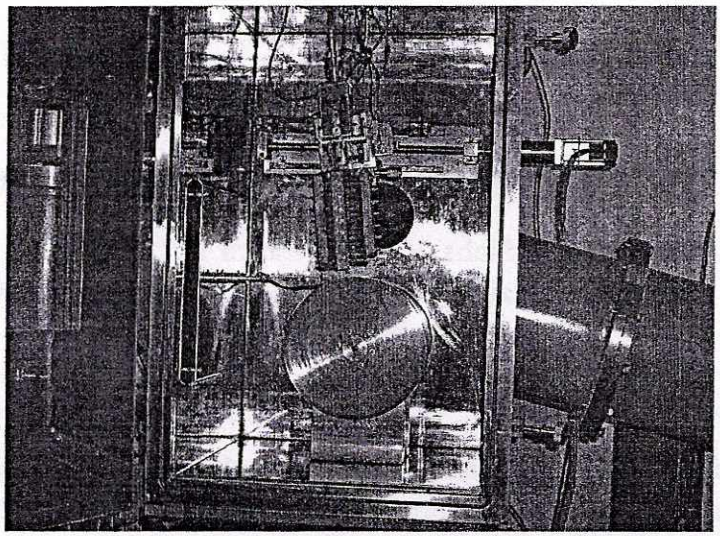

Fig. 1 : Photograph of the melt spinning system

strongly depends on alloy design with large number of alloying elements to restrict the structural changes during cooling of the melt by achieving certain requisite thermodynamic parameters like heat of mixing, variation of atomic sizes etc. Due to their unique structures of dense and random atomic configurations, BMGs exhibit excellent properties such as ultrahigh strength, large elastic elongation, high corrosion resistance, surface superflatness and viscous deformability.

Though most of the initial research on bulk metallic glass formation has been focused on non-ferrous metals, the isotropy in the structure was of immediate curiosity from magnetic point of view. Eventually, development of Fe - based bulk metallic glasses was explored as a possible material for large sized soft magnetic components. Magnetic properties of bulk amorphous rod of $Fe_{72}Si_4B_{20}Nb_4$ (at%) alloy having typical dimensions of 2mm diameter and 60 mm length, produced by copper mould casting technique was investigated. The as-cast rod showed amorphous structure as observed from broad halo in the x-ray diffractogram. The material has supercooled region (ΔT_x, difference of first crystallization temperature and glass transition temperature) of about 50 K. The bulk amorphous rod in its as-cast state exhibited a fairly low coercivity of 212 mOe and high mechanical hardness of 1250Hv.