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Thesis Title Glass Forming Ability and Stability Bulk Zr-based and Marginal Al-based Glasses

SYNOPSIS

Bulk metallic glasses have emerged as a new class of engineering material over the last two decades In the present work Miedema's model has been applied to predict the glass forming ability of (Zr, Ti, Hf)-(Cu, Ni) binary and ternary alloys The crystallisation behaviour of Zr-based bulk and Al-based marginal glass forming alloys has been studied by X-ray diffraction, electron microscopy and differential scanning calorimetry

Thermodynamic prediction of glass forming range is a major challenge Different free energy models have been used to evaluate ideal glass transition temperatures of Zr, Ti, Hf, Cu and Ni The glass forming composition range in binary Zr-Ni, Ti-Ni, Hf-Ni, Zr-Cu, Ti-Cu, Hf-Cu and ternary Zr-Ti-Ni, Zr-Hf-Ni, Ti-Hf-Ni, Zr-Ti-Cu, Zr-Hf-Cu, Ti-Hf-Cu systems has been determined by Miedema's model. The glass forming composition range of nickel bearing alloys is comparatively higher than that of the copper bearing alloys The mixing enthalpy and mismatch entropy of the ternary (Zr, Ti, Hf)-(Cu, Ni) alloys, calculated by the extended regular solution model, vary between –15 to –42 kJ/mol and 0.13 to 0.25 respectively

Eight ternary alloys of nominal composition $Zr_{41.5}Ti_{41.5}Ni_{17}$, $Zr_{25}Ti_{25}Ni_{50}$, $Zr_{41.5}Hf_{41.5}Ni_{17}$, $Ti_{41.5}Hf_{41.5}Ni_{17}$, $Zr_{25}Ti_{25}Cu_{50}$, $Zr_{34}Ti_{16}Cu_{50}$, $Zr_{25}Hf_{25}Cu_{50}$ and $Ti_{25}Hf_{25}Cu_{50}$ have been melt-spun at 40 ms^{-1} wheel speed in order to produce ribbons The chosen alloy compositions fall approximately in the same region of the ternary phase diagram The glass forming ability and the crystallisation behaviour of the different alloy systems are quite different The copper bearing alloys tend to phase separate The Zr-Ti-Ni alloy precipitates quasicrystals, which is transformed to cF96 $NiZr_2$ phase upon prolonged heat treatment The glass forming ability of the Zr-Hf-Ni alloy is lower than that of the Zr-Ti-Ni alloy, which is attributed to the low atomic radii mismatch between Zr and Hf The difference in the crystallisation behaviour between the copper and the nickel bearing alloys has been explained by using the concept of Mendeleev number originally proposed by Pettifor in Pettifor Structure Maps The glass forming ability has been explained by taking into account the binary heat of mixing and the atomic radii mismatch of the constituent elements The cF96 Zr_2Ni is typically anti-Laves phase, which is having a very similar polyhedral network as that of the Laves phase Phases precipitated during processing and at the initial stages of crystallisation indicate that Frank-Kasper co-ordination polyhedra exist in the amorphous alloys

Quaternary and quinary alloys of nominal composition $Zr_{55}Cu_{30}Ni_5Al_{10}$ and $Zr_{60}Cu_{15}Ni_{10}Al_{10}Pd_5$ have been cast in copper mould in the form of 3mm diameter rods In the as-cast condition, precipitates of Zr_2Ni and $(Cu, Ni)_{10}Zr_7$ phase can be seen in the amorphous matrix After crystallisation of the amorphous phase the same nanocrystalline phases are precipitated Both the cubic and tetragonal modifications of the Zr_2Ni phase are observed after heat treatment in Zr-Cu-Ni-Al-Pd alloy Due to the lower cooling rate quasicrystallisation in these alloys could not be observed As the cF96 Zr_2Ni phase is observed in both the alloys in as-cast condition, these alloys are also expected to have same Frank-Kasper polyhedra in the liquid and the amorphous phase

Development of light weight metallic glasses is strategically important, though bulk metallic glasses can not be synthesised in aluminium alloys Five alloys of nominal composition $Al_{87}Fe_5Ni_5La_3$, $Al_{88}Fe_3Ni_3La_6$, $Al_{82}Fe_4Ni_4La_{10}$, $Al_{75}Ti_{10}Ni_{10}La_5$ and $Al_{75}Ti_{10}Ni_{15}$ have been studied In Al-Fe-Ni-La alloy the glass forming ability increases with the increase in lanthanum content Below a certain amount of lanthanum, the precipitation of mainly α-Al can be seen Glass forming ability of Al-Ti-Ni-La alloy is higher than that of Al-Ti-Ni alloy In both alloys the precipitation of Al_3Ti phase can be observed Amorphous alloy in Al-Fe-Ni-La system crystallises in three exothermic events giving rise to the precipitates of α-Al, LaNi and Al_3La phases The glass forming ability can be explained by taking into account binary heat of mixing and atomic radii mismatch With the progress in crystallisation the matrix becomes richer in solute The phases precipitated at the initial stages of crystallisation of a lanthanum based bulk metallic glass are stoichiometrically similar to the phases precipitated at the end of crystallisation of the aluminium based glass Thus a connection can be established between aluminium based metallic glasses and lanthanum based bulk metallic glasses