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SYNTHESIS ROUTE DEPENDENC ON ICOSAHEDRAL PHASE FORMATION FROM METALLIC GLASS

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A wide variety of metallic glass alloys have been found to yield a meta-stable quasicrystalline icosahedral primary devitrification product. Many studies suggest a linkage between the short-range order of the amorphous phase and the formation of quasicrystals. These suggestions are based on the speculation that the liquid prior to vitrification contains icosahedral short range order or clusters, which are retained in the glass upon quenching. The concept of icosahedral order in liquids is not new and has been considered theoretically since the mid-1980's. Experimental evidence that conclusively shows icosahedral order in these glasses does not yet exist, although a number of recent studies provide evidence that strongly support its existence. The objectives of this current work are to process amorphous, quasicrystal-forming alloys (e.g., Zr-Pd-Cu) by solid state routes and compare their devitrification behavior to glasses obtained by conventional melt spinning. We speculate that solid-state synthesis does not provide the opportunity to form the initial icosahedral short-range order as proposed in liquid-to-solid routes. Our results indicate that meta-stable quasicrystals do not form from amorphous Zr-Pd-Cu alloys obtained by mechanical milling of crystalline ingots. Instead, only a single crystallization event occurs to form the stable crystalline phase. Furthermore, mechanical milling of amorphous melt spun ribbons leads to the same devitrification path as the mechanically milled crystalline ingot. The formation of an amorphous structure by mechanical milling is supported electron microscopy and by synchrotron X-ray diffraction. Isothermal differential scanning calorimetery of the mechanically milled materials indicates nucleation from an amorphous matrix rather than growth of existing nuclei. These results from this work suggest that the absence of short-range icosahedral order in an amorphous structure precludes the formation of a meta-stable quasicrystalline phase and favors primary crystallization of a stable, crystalline phase.

NANO/MICROFORMING OF BULK METALLIC GLASSES

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Bulk metallic glasses exhibit an obvious glass transition phenomenon and supercooled liquid state in a wide temperature range. The materials exhibit Newtonian viscous flow under very low stresses in the supercooled liquid temperature range and furthermore, the material exhibit superior micro/nano formability and good geometrical transferability of die. The present paper demonstrates the macroscopic and microscopic deformation behavior of La-, Zr-, Pd- and Pt-based bulk metallic glasses and the application of these alloys to fabrication of various microparts for micromachines or Micro-Electro Mechanical Systems (MEMS). The principle of the microformability evaluation method is to measure the geometrical transferability of nanometer-sized die shapes to the material by die-forging. For this evaluation system, V-grooved micro dies of (100)Si were fabricated by electron beam lithography and anisotropic etching. The V-groove dies are from 100 nm to 1 micrometers wide, and the bottom angle of the V-shape is 70.6 degree. After the forming, the transferred shape of the material is measured with AFM. Nano/Microforming techniques are shown as follows; microextrusion with micro-dies made of photochemically machinable glass and made of laser-micromachined polyimide, submicron imprinting with silicon die fabricated by EB lithography and etching, microforging of microgear of 10 micrometers in module with microdie fabricated by UV-LIGA process and Ni-electroforming, microforging of micro cantilever beam with laser-micromachined polyimide die. As a result, bulk metallic glasses are highly useful for realizing high-performance micro-structures due to their excellent characteristics as functional and structural materials, including isotropic homogeneity free from crystalline anisotropy on micrometer and nanometer scales.

INFLUENCE OF EXTERNAL CLUSTERS ON SOLIDIFICATION OF GLASS-FORMING Zr-BASED ALLOY

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Samples of glass-forming ZrNiCuTiBe alloy were melted and undercooled by fluxing method. In order to study the influence of clusters on phase selection of the undercooled melt, external clusters were introduced onto the undercooled melt. The clusters were produced by ion beam sputtering of targets. The types of the cluster can be determined by changing target materials, and the size of the cluster can be changed by changing experimental factors. When the melt was undercooled to the temperature wanted, clusters were then introduced to trigger the undercooled melt. Two different triggering ways were used in the experiments, triggering at some given undercooling levels, isothermal triggering, and triggering during continuous cooling of the melt, continuous triggering. As a result, nucleation of the undercooled melt was successfully induced by both of isothermal triggering and continuous triggering. It was found that the ability to induce nucleation of undercooled ZrNiCuTiBe alloy melt was different for different kind of clusters, in the sequence of Zr, Cu, Ni, Ti clusters with Zr clusters being the highest to induce nucleation. And different kind of primary phase was obtained using different type of clusters. Therefore, the phase formation is directly related to the cluster evolution in the undercooled melt. On the bases of the current nucleation theory, the cluster-inducing effects on nucleation are studied, especially on the interaction between the external clusters introduced and the internal clusters in the undercooled melt. Special attention is paid on analyzing the cluster evolution with increasing undercooling before nucleation. The cluster evolution effect on formation of amorphous phase is also studied.

EUTECTIC SOLIDIFICATION UNDER ULTRA-HIGH GRAVITY

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The crystallization of metallic liquids has been investigated under the influence of high inertial forces up to 80,000 **g** (**g**= gravitational acceleration). In the case of Si-Au, which was processed for several hours above the melting point and slowly cooled to room temperature, scanning electron microscopy resolves the formation of primary Si, eutectic Si-Au, and primary Au along the gravitational field. This effect can only be explained by a concentration gradient developing in the liquid caused by a modification of the chemical potentials of the elements involved. We demonstrate that at these high accelerations the equilibrium phase diagram is spread out over ranges of concentration and pressure. Theoretical considerations are in good agreement with the experimental data. In addition, we demonstrate that eutectic compositions can also be identified and isolated in multi-component metallic alloys. Thus, high-temperature centrifugation is a new and efficient method to discover compositions having the potential of forming bulk metallic glasses.