METASTABLE STRUCTURES IN RAPIDLY QUENCHED METALS AND ALLOYS

by

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ABSTRACT

The formation and decomposition of metastable structures in liquid-quenched and vapour-quenched metals and alloys have been investigated using transmission electron microscopy, electron diffraction, X-ray diffraction, Auger electron spectroscopy, X-ray photoelectron spectroscopy, differential thermal analysis and resistivity measurement techniques.

Metastable phases have been observed in Pb, Sb and Bi on rapid quenching from liquid/vapour. These phases are correlated to the high pressure phases of these elements, and transform to the equilibrium phases on heating. Effects of quenching parameters on the stabilization of the metastable phases have been investigated. It is shown that the shock wave intensity of the gun in liquid-quenching and temperature of the substrate in vapour-quenching play a significant role in the stabilization of the metastable phases. The transformation temperatures and corresponding heats of transformation of the metastable phases have been investigated.

Metastable crystalline/amorphous solid solutions are obtained in PbGe system on rapid quenching from liquid/vapour. It is shown that the Pb-rich fcc phase can retain upto $\sim$ 13 at % Ge on liquid-quenching and upto $\sim$ 7.5 at % Ge on vapour-quenching. For Ge-rich

compositions, upto $\sim$ 7.5 at % Pb can be retained in amorphous Ge matrix by vapour-quenching but there is no detectable solubility of Pb in crystalline Ge obtained by liquid-quenching. Auger electron spectroscopy studies suggest that these phases are random homogeneous solid solution. No preferred segregation of any of the constituents on the surface is observed. XPS studies show that the binding energy of the core electrons of Ge increases in the Pb-rich crystalline solid solutions with a charge transfer of $\sim$ 0.4 electrons from Ge to Pb. In Ge-rich amorphous solid solutions, however, the charge transfer is nondetectable. The Pb-rich crystalline phase decomposes by a process of continuous precipitation and requires an activation energy of $\sim$ 1.2 eV. Transformation of the Ge-rich amorphous phase proceeds via polymorphous crystallization into a Ge-rich crystalline solid solution. The transformation temperature, T_c, heat of transformation, H_c and activation energy associated with the transformation process, E decrease on increasing the metal concentration. Crystallization is nucleation and growth controlled, requiring higher thermal activation for nucleation than for the growth process.

Our observations suggest that liquid-quenching is more effective in producing metastable crystalline phases whereas vapour-quenching is effective in stabilizing the amorphous phases.

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