Coupled Growth in Hypermonotectics (Primary Experiment)
and
Wetting Characteristics of Immiscible (Glovebox Investigation)

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This Summary covers both a flight experiment studying solidification in immiscible alloy systems and a related Glovebox investigation on wetting behavior of immiscible systems.

Objective – Coupled Growth in Hypermonotectics

The overall objective of this project is to obtain a fundamental understanding of the physics controlling solidification in immiscible alloy systems. The investigation involves both experimentation and the development of a model describing solidification in monotectic systems. The experimental segment is designed to first demonstrate that it is possible to obtain interface stability and steady state coupled growth in hypermonotectic alloys through microgravity processing. This segment will also permit experimental determination of the limits of interface stability and the influence of alloy composition and growth rate on microstructure. The objectives of the modeling segment of the investigation include prediction of the limits of interface stability, modeling of convective flow due to residual acceleration, and the influence of surface tension driven flows at liquid-liquid interfaces.

Need for a Microgravity Environment – Coupled Growth in Hypermonotectics

The study of solidification processes in immiscible alloy systems is hindered by the inherent convective flow which occurs on the Earth and by the possibility of sedimentation of the higher density immiscible liquid phase. Processing using a high thermal gradient and a controlled growth rate can theoretically lead to a stable macroscopically planar growth front even in hypermonotectic alloys. Processing under these conditions should avoid constitutional supercooling and actually prevent the formation of the minor immiscible liquid phase in advance of the solidification front.

Another problem occurs due to the solute depleted boundary layer, which is expected to form in advance of the solidification front in these alloy systems. This boundary layer is almost always less dense than the liquid away from the solidification front. As a result, convective instability is expected for these alloys. Ground-based testing has indicated that convection is a problem in these alloy systems and leads to gross compositional variations along the sample and possibly even difficulties in maintaining interface stability. Sustained low gravity processing conditions are

necessary in order to minimize these problems and facilitate solidification under conditions which approach steady state.

Results to Date – Coupled Growth in Hypermonotectics

Primary activities for this project have involved the analysis of flight samples processed during the LMS mission (June 20-July 7, 1996) and ground based samples processed shortly afterwards. Computed tomography data initially revealed the presence of voids in some of these samples. Most testing has focused on determining the source of these voids. A major portion of this effort has involved the development of a testing apparatus that could determine what gases, if any, have been present within the voids. All ampoules were opened in this apparatus and initial analyses of the gases present have been made. Additional testing of ampoule assemblies and metallographic analysis is underway.

Objective – Wetting characteristics of Immiscibles

The objective of this Glovebox investigation was to determine the influence of alloy/ampoule wetting characteristics on the segregation of immiscible liquids during microgravity processing. While all operative segregation mechanisms are not completely understood, one of the most important appears to be driven by perfect wetting of one of the liquids on the ampoule wall.

Need for a Microgravity Environment – Wetting Characteristics of Immiscibles

One-g processing of immiscible systems generally leads to either sedimentation or flotation of the droplets in the cell. Drag of the droplets along the bottom or top of the cell impedes droplet migration and observation of mechanisms active. Low-g processing conditions help minimize these difficulties.

Results – Wetting Characteristics of Immiscibles

A series of twelve samples covering a range of compositions in the transparent succinonitrile glycerin system was processed during the USMP-4 flight in November 1997. A real-time video downlink of the events during processing allowed observation of segregation processes. Perfect wetting and separation was observed in two of the twelve samples.