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GROWTH OF SOLID SOLUTION SINGLE CRYSTALS

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The solidification of a solid solution semiconductor, having a wide separation between liquidus and solidus has been extensively studied in ground based, high magnetic field and Spacelab experiments. Two alloys of mercury cadmium telluride have been studied; with 80.0 mole percent of HgTe and 84.8 mole percent of HgTe respectively, the remainder being cadmium telluride. Such alloys are extremely difficult to grow by directional solidification on earth due to high solutal and thermal density differences that give rise to fluid flow and consequent loss of interface shape and composition. Diffusion controlled growth is therefore impossible to achieve in conventional directional solidification. The ground based experiments consisted of growing crystals in several different configurations of heat pipe furnaces, NASA's Advanced Automated Directional Solidification Furnace (AADSF), and a similar furnace incorporated in a superconducting magnet capable of operating at up to 5T. The first microgravity experiment took place during the flight of STS-62 in March 1994, with the AADSF installed on the second United States Microgravity Payload (USMP-2). The alloy was solidified at 3/4 inch per day over a 9 day period, and for the first time a detailed evaluation was performed correlating composition variations to measured residual acceleration. The second flight experiment took place in the fourth United States Microgravity Payload Mission (USMP-4) in November 1997. Due to contamination of the furnace system, analysis shows that the conditions prevailing during the experiment were quite different from the requirements requested prior to the mission. The results indicate that the sample did accomplish the desired objectives.

As with the USMP-2 mission, the results of the ground based experiments were compared with the crystal grown in orbit under microgravity conditions. On the earth, it has been demonstrated that the application of the magnetic field leads to a significant reduction in fluid flow, with improved homogeneity of composition. Theoretically the field strength required to suppress flow increases with the diameter of the material. The 8 mm diameter sample used here was less than the upper diameter limit for a 5T magnet. As the configuration for USMP-4 was changed so that the material was seeded and other processing techniques were also modified, it was decided to examine the effects of a strong magnetic field under the modified configuration and parameters. A further change from USMP-2 was that a different composition of material was grown, namely with 0.152 mole fraction of cadmium telluride rather than the 0.200 of the USMP-2 experiment. The objective was to grow highly homogeneous, low defect density material of a composition at which the conduction band and the valence band of the material impinge against each other.

As indicated, the furnace was contaminated during the mission. As a result of solid debris remaining in the furnace bore, the cartridge in this experiment was significantly bent during the insertion phase. During translation the cartridge scraped against the plate which isolates the hot and cold zones of the furnace. Thermocouples indicated that a thermal asymmetry resulted. The scraping in the slow translation or crystal growth part of the processing was not smooth and it is probable that the jitter was sufficient to give rise to convection in the melt. Early measurements of composition from the surface of the sample showed that the composition varies in an oscillatory manner. Following sectioning, microprobe analysis confirmed that there was considerable compositional variation in both radial and transverse directions.