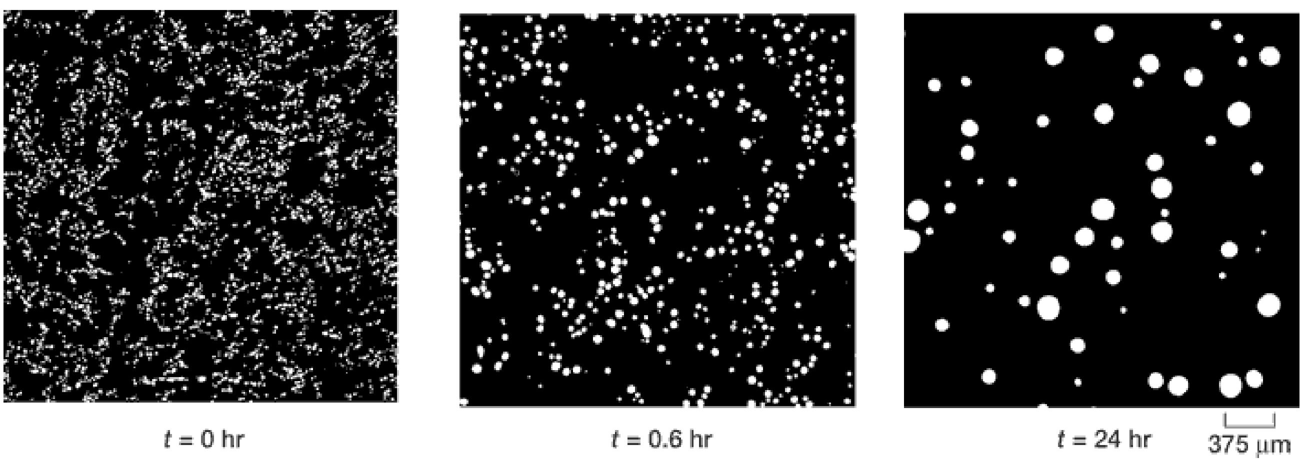
Coarsening Experiment Prepared for Flight

The Coarsening in Solid-Liquid Mixtures-2 (CSLM-2) experiment is a materials science spaceflight experiment whose purpose is to investigate the kinetics of competitive particle growth within a liquid matrix. During coarsening, small particles shrink by losing atoms to larger particles, causing the larger particles to grow. In this experiment, solid particles of tin will grow (coarsen) within a liquid lead-tin eutectic matrix. The following figures show the coarsening of tin particles in a lead-tin (Pb-Sn) eutectic as a function of time. By conducting this experiment in a microgravity environment, we can study a greater range of solid volume fractions, and the effects of sedimentation present in terrestrial experiments will be negligible. The CSLM-2 experiment flew November 2002 on space shuttle flight STS-113 for operation on the International Space Station, but it could not be run because of problems with the Microgravity Science Glovebox in the U.S. Laboratory module. Additional samples will be sent to ISS on subsequent shuttle flights.

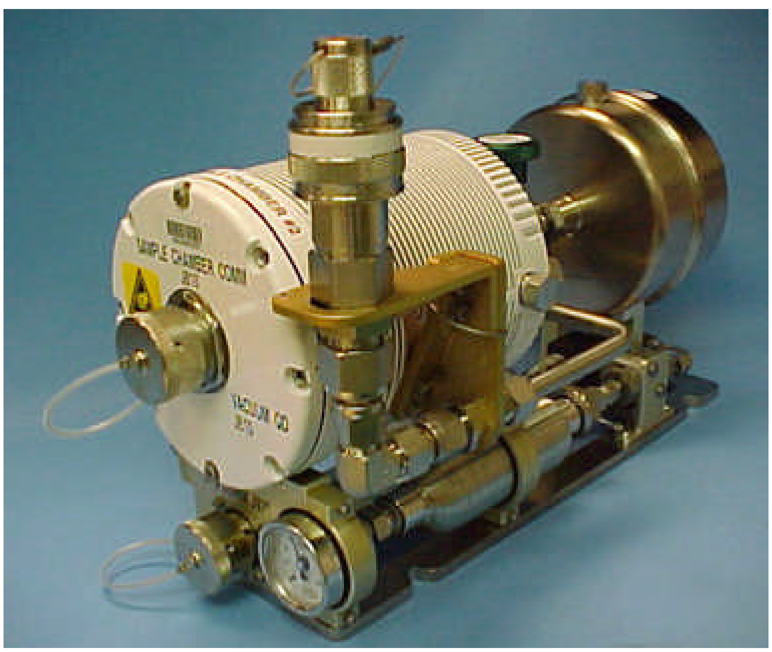


Solid Sn particles in a liquid Pb-Sn alloy. The size of the particles increases with coarsening time t. In many materials, such as Ni-based superalloys used in jet turbine blades, this increase in size has a dramatic effect on the properties of the alloy.

The coarsening of particles within a matrix is a phenomenon that occurs in many metallic and other systems. For example, the second-phase particles in high-temperature turbine blade materials undergo coarsening at the operating temperature of the turbine. The coarsening process degrades the strength of the blade because turbine alloys containing a few large particles are weaker than those containing many small ones. Coarsening occurs in liquid-phase sintered materials such as tungsten carbide-cobalt, iron-copper, dental amalgam for fillings, and porcelain. The growth of liquid droplets in a vapor phase that occurs inside rain clouds (particularly near the equator, where the vapor pressure of water is high) is a commonplace example of the coarsening phenomenon. The CSLM-2 study will help define the mechanisms and rates of coarsening that govern all these systems.

In fiscal year 2002, the CSLM-2 project completed the fabrication, assembly, and testing of the flight hardware. The flight hardware consists of two main pieces of equipment, the sample processing unit (SPU) and the electronics control unit (ECU), as shown in the following photographs. The SPU incorporates a small electric sample heater with a water quench system. The heater consists of a circular sample holder plate sandwiched by two thin-film kapton heaters with a circular ring heater around the perimeter. The holder plate has four cylindrical sample holes with four platinum resistance temperature devices for temperature monitoring and control.

CSLM-2 sample processing unit.



CSLM-2 electronics control unit.

The ECU contains the power supply, electrical control, and data storage components. There are three toggle switches on the front of the ECU that allow a crew member to power up the unit, activate the experiment run, and manually abort the run if necessary. There are also three indicator lights and a liquid crystal display (LCD) that show the status of the experiment and the temperatures of the resistance temperature devices in the sample holder. The temperature-time data from the experiment run are stored on a hard disk located in the ECU and telemetered to the NASA Telescience Support Center after experiment completion.

The CSLM-2 experiment runs do not need to be attended by an astronaut after activation. There is no need for real-time orbit-to-ground telemetry directly from the experimental apparatus. Non-real-time data will be downlinked via the Microgravity Science Glovebox laptop connected to the CSLM-2 hardware by an RS-422 data downlink.

References

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