VAPOR CRYSTAL GROWTH STUDIES OF SINGLE CRYSTALS OF MERCURIC IODIDE (3-IML-1)

Lodewijk van den Berg
EG&G Energy Measurements, Inc.
Santa Barbara Operations
Goleta, California USA

BACKGROUND

A single crystal of mercuric iodide (HgI_2) will be grown during the IML-1 mission. The crystal growth process takes place by sublimation of HgI_2 from an aggregate of purified material (the source), transport of the molecules in the vapor from the source to the crystal, and condensation on the crystal surface.

The equipment used is the Vapor Crystal Growth System (VCGS), primarily consisting of an experiment enclosure in which the furnace and growth ampoule are installed, a temperature control system, an air circulation system to provide the proper amount of cooling and a microscope to observe the growing crystal. The system is installed in a half-rack of the Spacelab.

The objectives of the experiment are:

a. To grow a high-quality crystal of HgI_2 of sufficient size so that its properties can be extensively analyzed; and

b. To study the vapor transport process, specifically the rate of diffusion transport at greatly reduced gravity where convection is minimized.

Single crystals of HgI_2 have technological applications as the critical sensing elements in x-ray and gamma ray detection systems. The radiation creates electronic charges in the detectors, and measurement of these charges makes it possible to determine the intensity and the energy of the radiation. The material has a very high resistivity at ambient temperatures so that cooling of the systems is not required and power consumption is minimal.

These systems can be used in environmental and personal monitoring, manufacturing operations, nuclear medicine, focal plane arrays for x-ray and gamma ray telescopes, and elemental analysis systems using x-ray fluorescence.

EXPERIMENT

The time-line of the IML-1 mission provides for the growth of one crystal.

In order to avoid the difficult and time-consuming process of seed initiation and selection during the space flight, a seed crystal has been grown pre-flight inside the ampoule using a prototype flight furnace. This activity at the same time provided the temperature parameters for continuation of the crystal growth during the flight.

At the start of the experiment the payload specialist will install the ampoule/furnace combination in the experiment enclosure and will initiate the growth procedure. The pre-programmed time-temperature sequence of the experiment is shown in Figure 1. The sequence exists of three phases: heat-up, growth, and cool-down. The software which controls the experiment is interactive, in the sense that the nominal times and temperatures preset in the software can be adjusted by the crew member to optimize the growth conditions. The growing crystal can be viewed through the microscope, and the observations and judgements of the crew member, in consultation with the P.I. team on the ground, are critical for a successful completion of the experiment.

The results of the experiment on Spacelab 3 showed that the system used to grow a crystal in microgravity makes it possible to produce a crystal of a structural quality never before observed and with electronic properties which had been thought unattainable. The experiment on IML-1 will be performed to validate these results while the crystal growth procedures are optimized based on the Spacelab 3 experience.

After the flight the whole crystal will be analyzed for structural quality and homogeneity by means of gamma ray diffraction rocking curves. The crystal subsequently will be processed into detector structures so that the transport properties of the electronic charge carriers can be measured. In addition, thin sections will be provided to NTIS for evaluation of the microscopic defect structure using a cyclotron-generated x-ray beam.

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References

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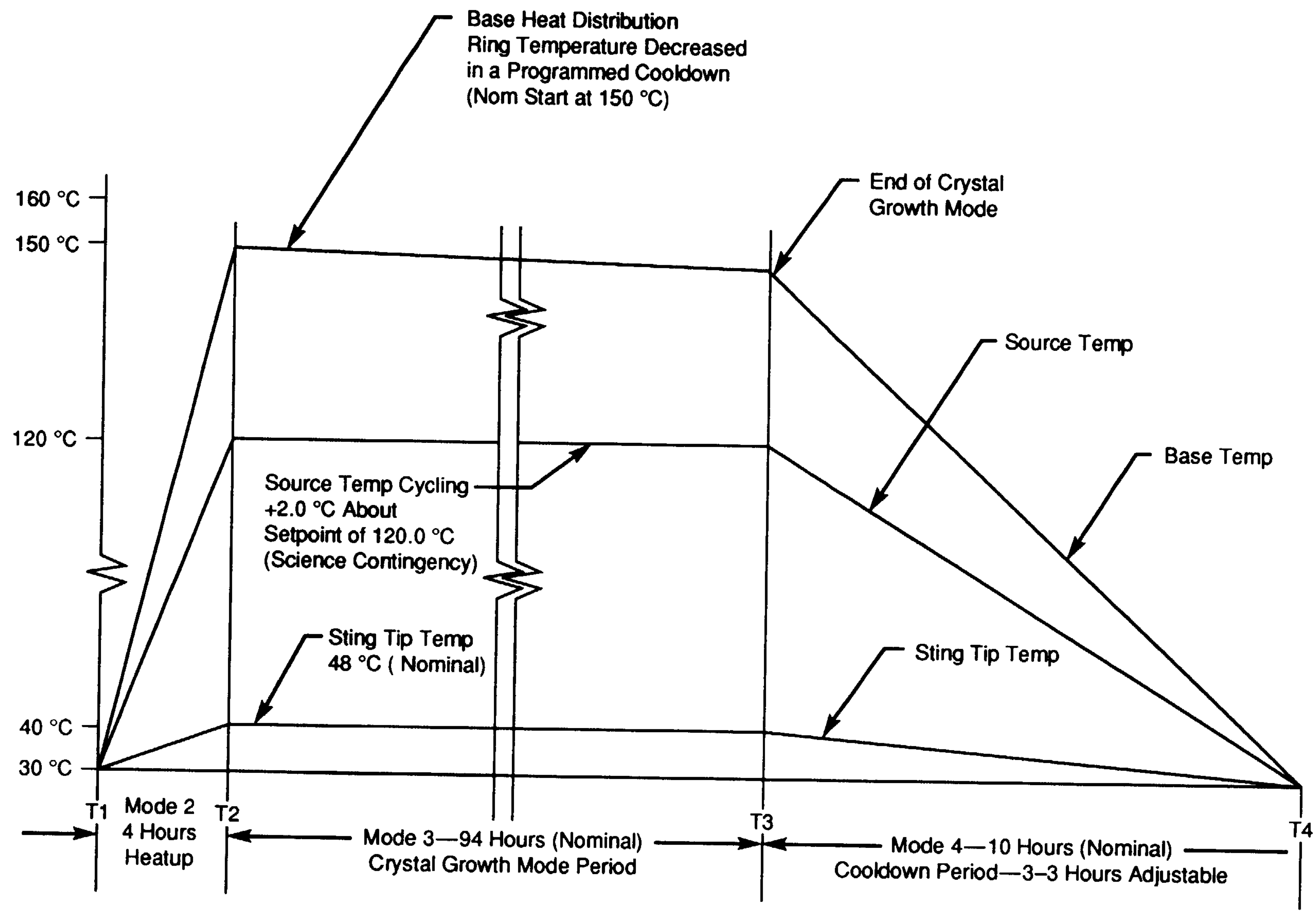

Figure 1. The Pre-Programmed Time-Temperature Sequence of the VCGS Experiment.