Dewetting and Segregation of Zn-Doped InSb in Microgravity Experiments

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Introduction

• Three Zn-doped InSb crystals were directionally solidified under microgravity conditions at the International Space Station

•The samples were processed in the Microgravity Science Glovebox

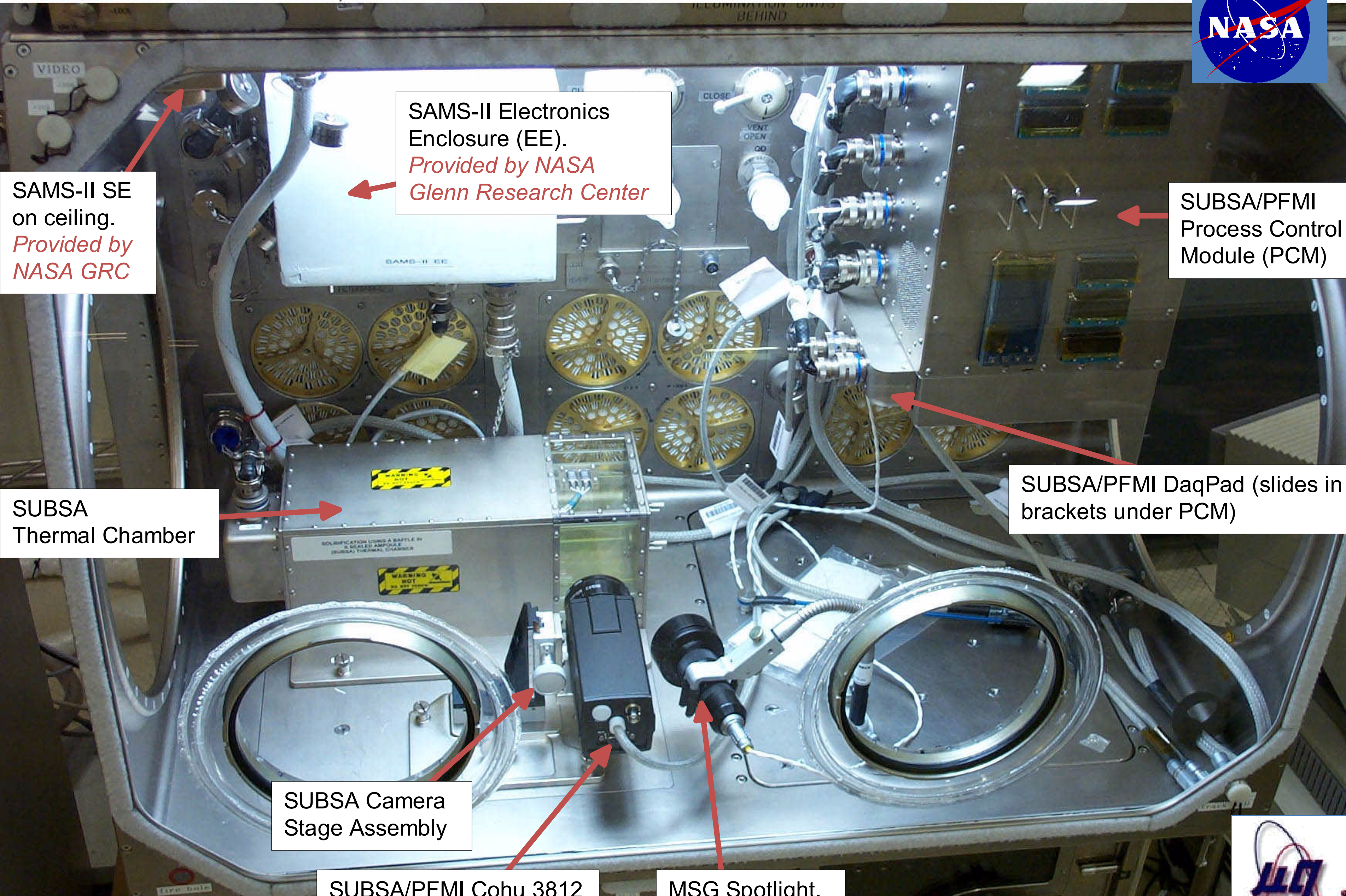
•The samples were grown by a Vertical Gradient Freeze technique. The furnace allowed for real-time visualization of the solid-liquid interface.

• Static pressure of ~4000 N/m^2 was imposed on the melt using a piston driven by a carbon spring in 2 of the 3 samples to prevent bubble formation and de-wetting

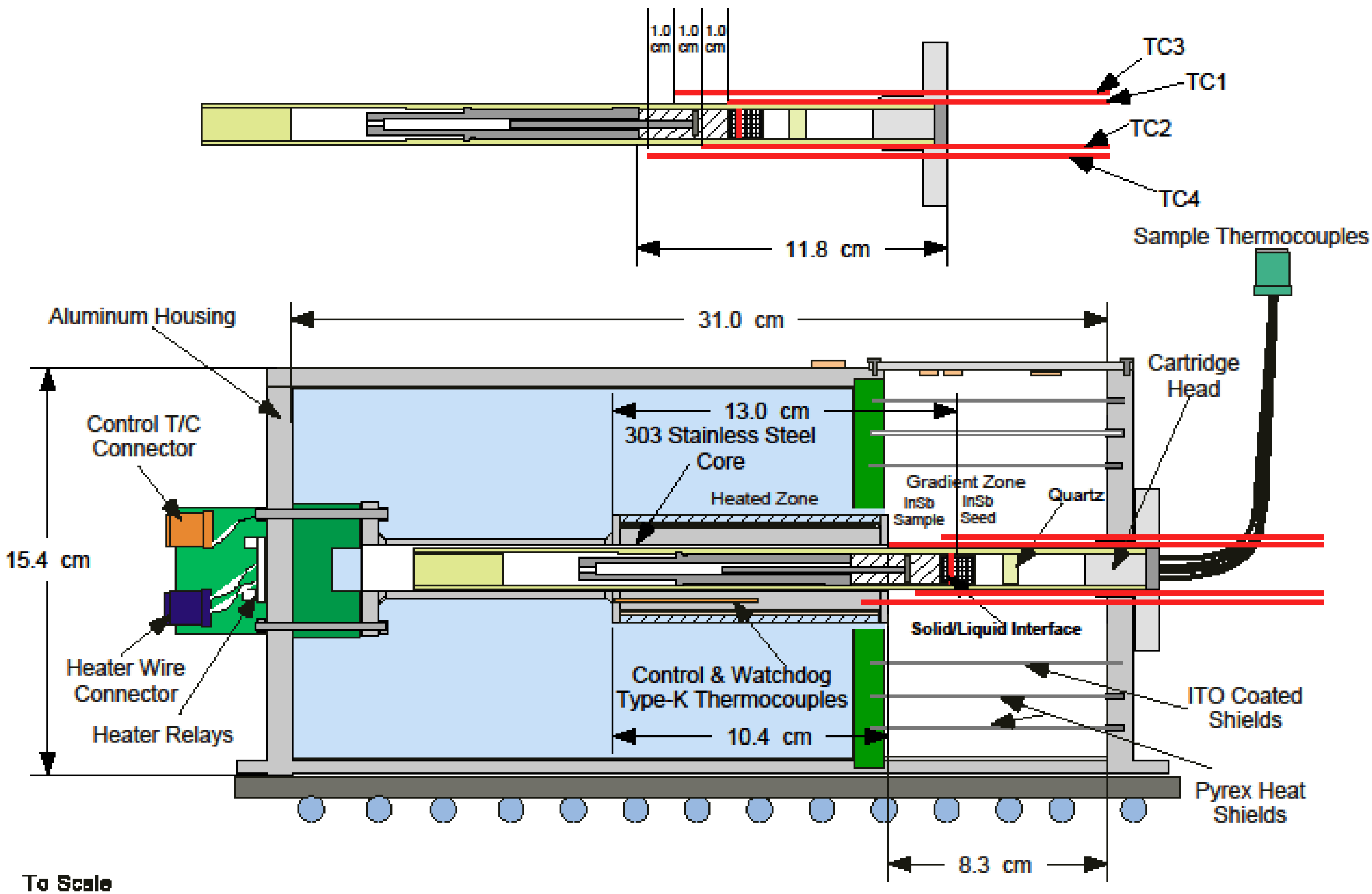
•X-ray tomography was used to identify the final positions of the carbon baffles inside the samples

•The distribution of Zn was measured using SIMS

PHOTO OF FLIGHT SUBSA SYSTEM IN MSG GROUND UNIT.
PHOTO TAKEN NOVEMBER 13, 2001

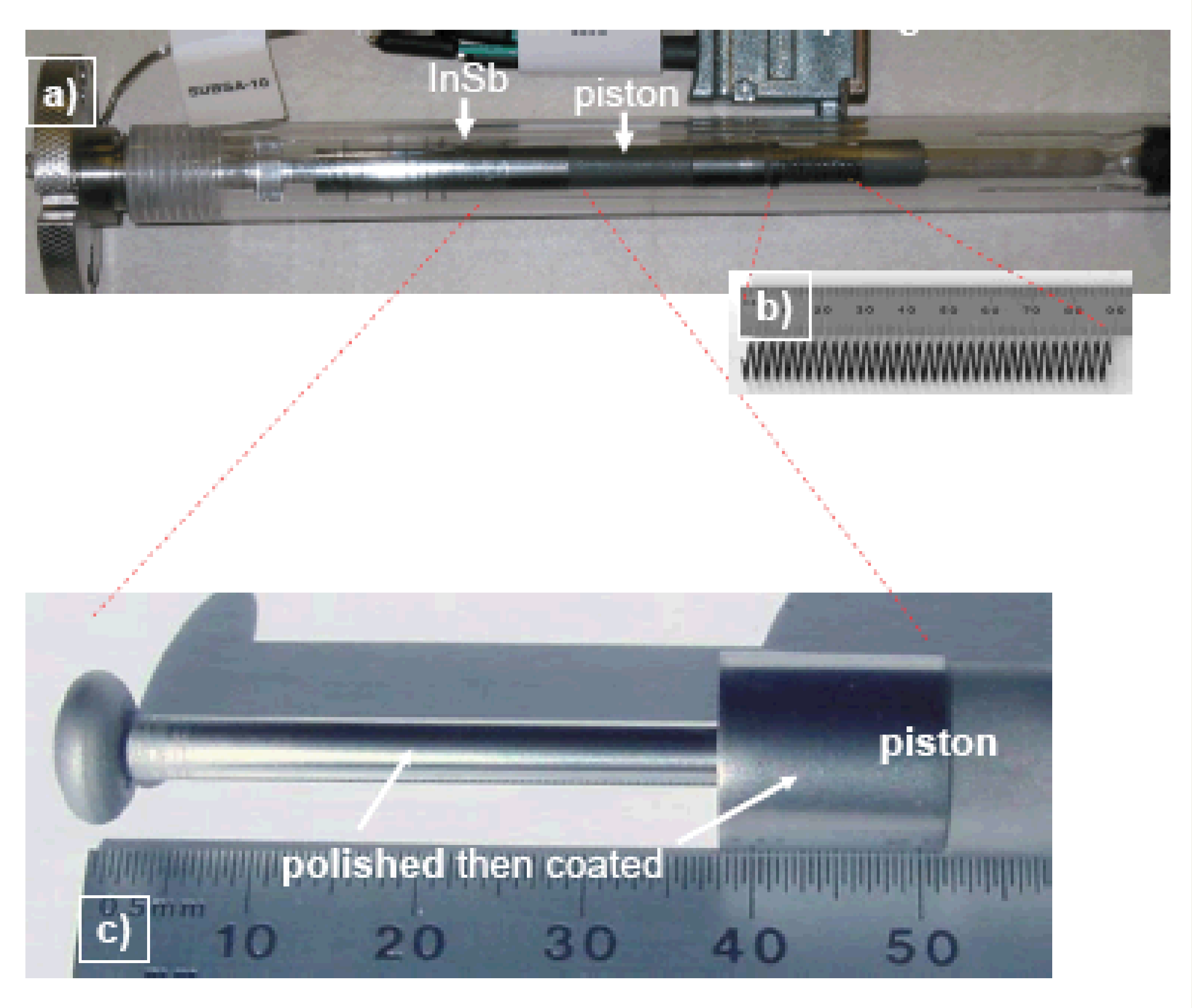


SUBSA Furnace

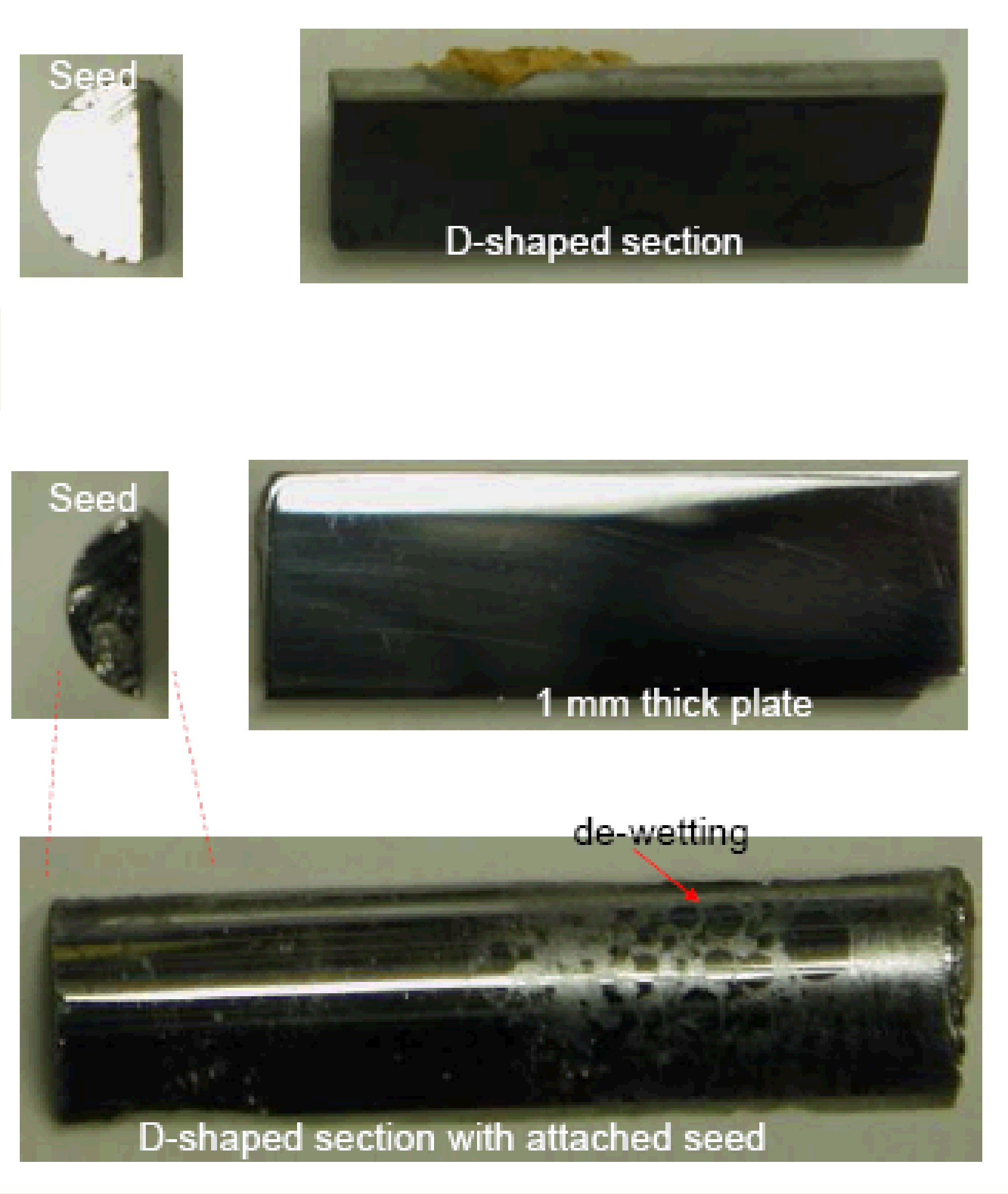


To Scale

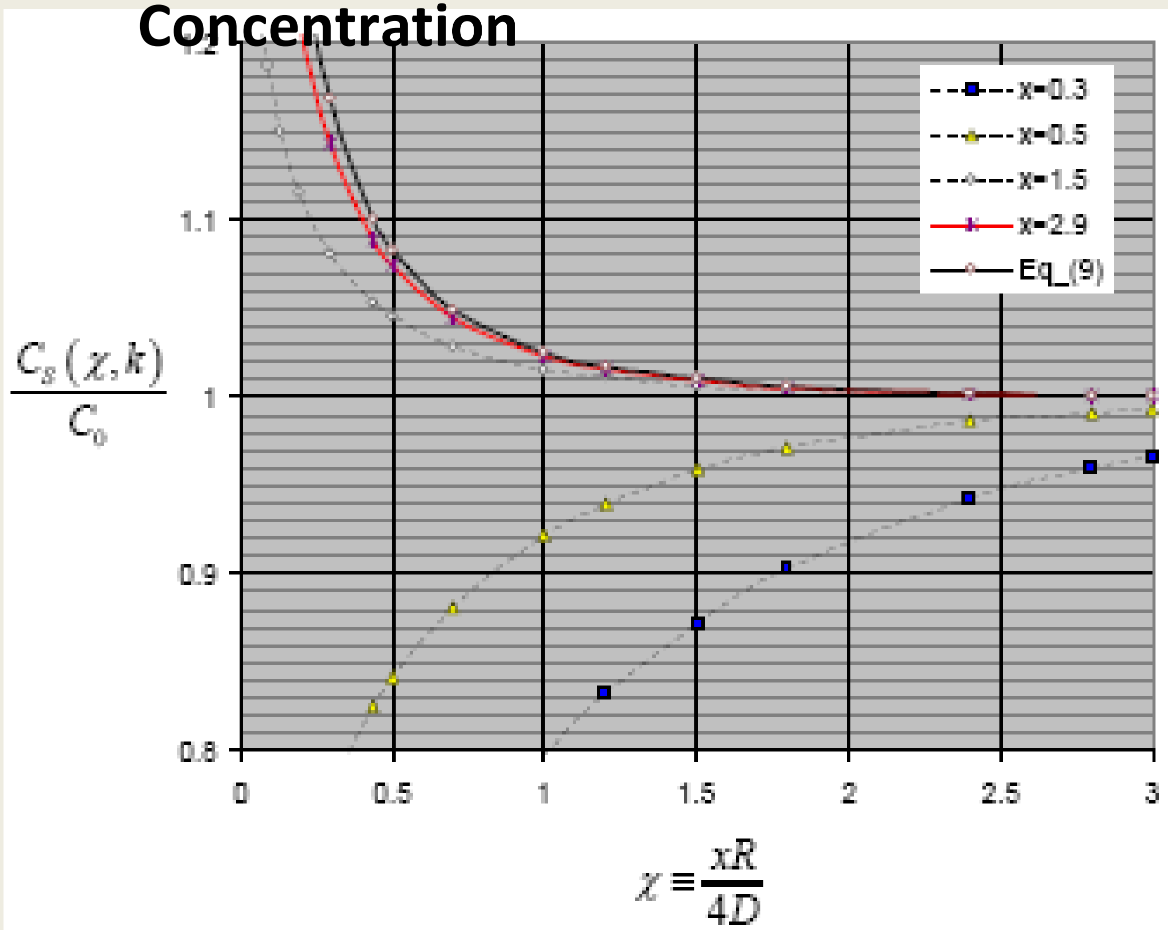
Ampoule Components



SUBSA-10 Post-growth Sample Processing

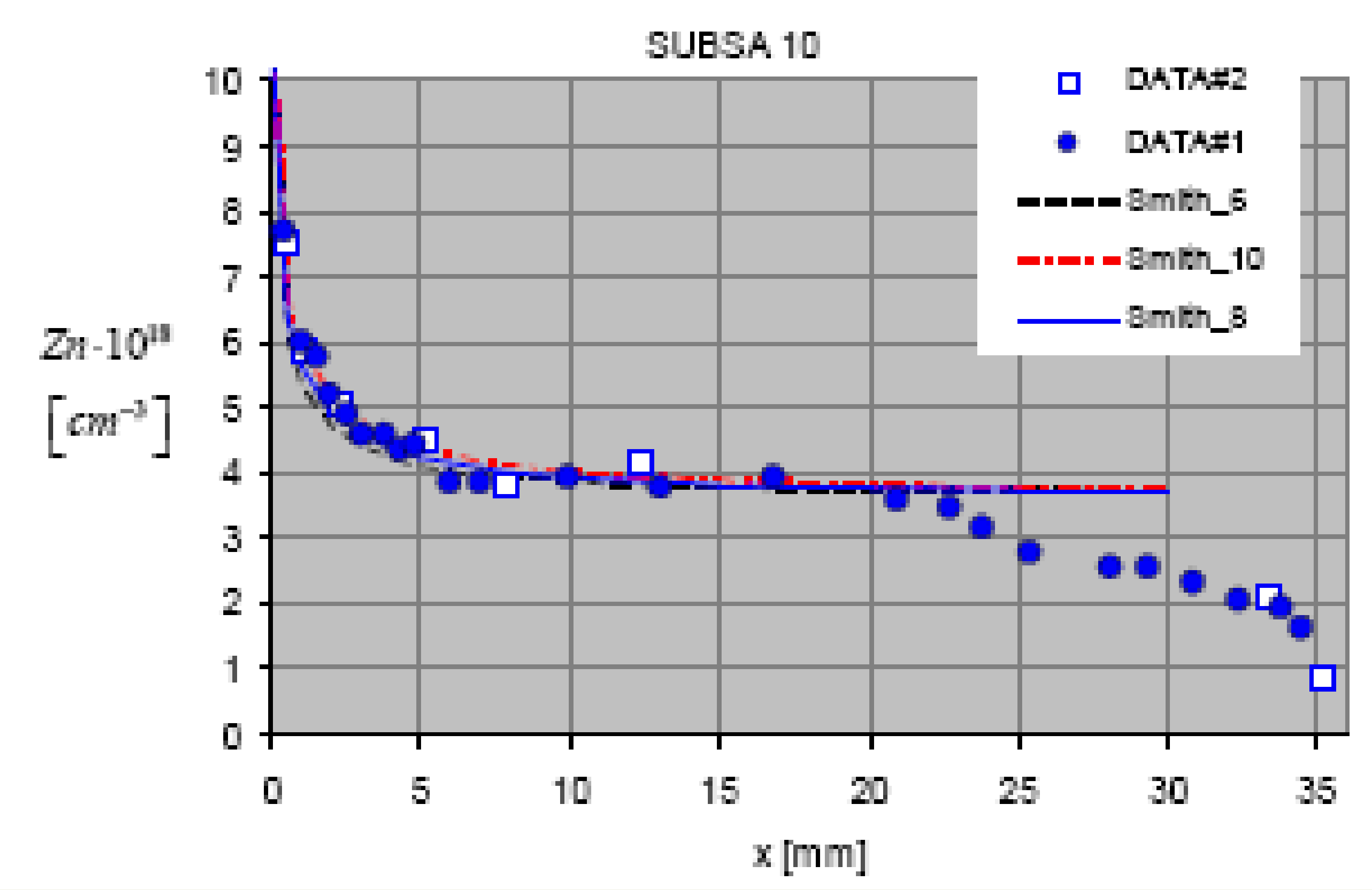


Initial Transient in Dopant Concentration



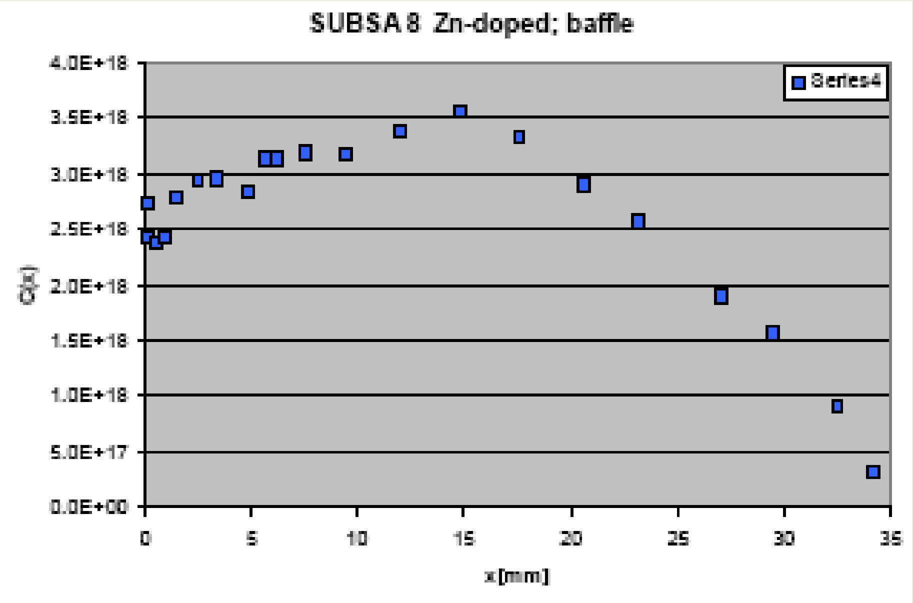
SUBSA-10 Dopant Segregation Profile

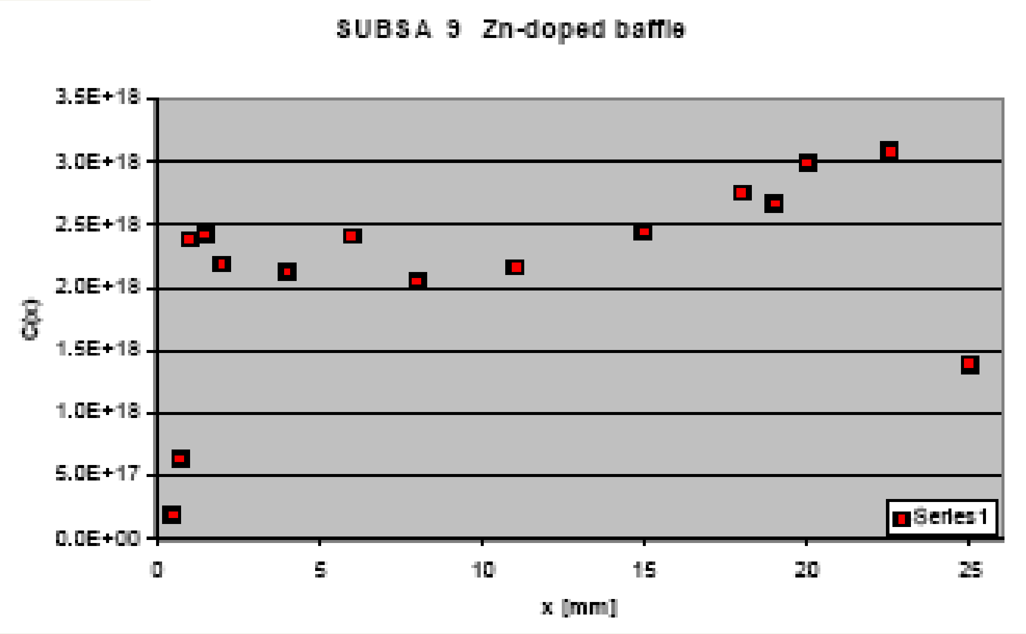
(less than 0.1 mm of the seed was melted)



SUBSA-08 and SUBSA-09 Dopant Segregation Profiles

(approximately 2 mm of the seeds were melted)

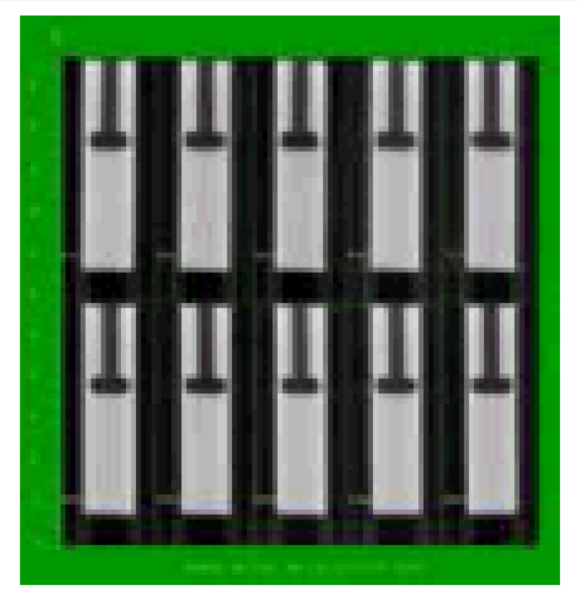




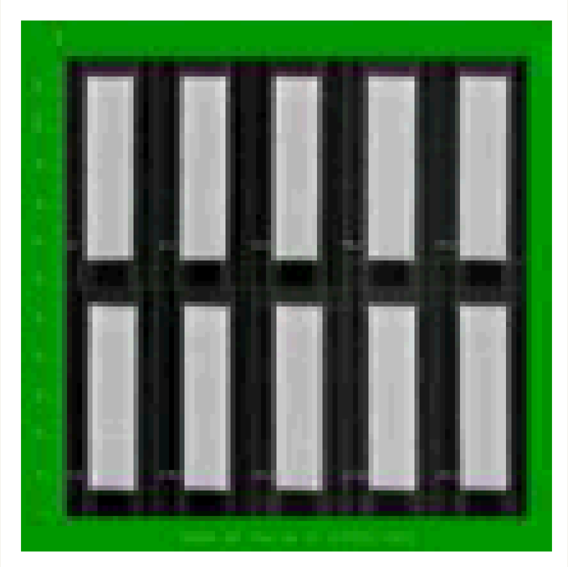
Computed tomography measurements of final baffle positions

SUBSA-08

SUBSA-09

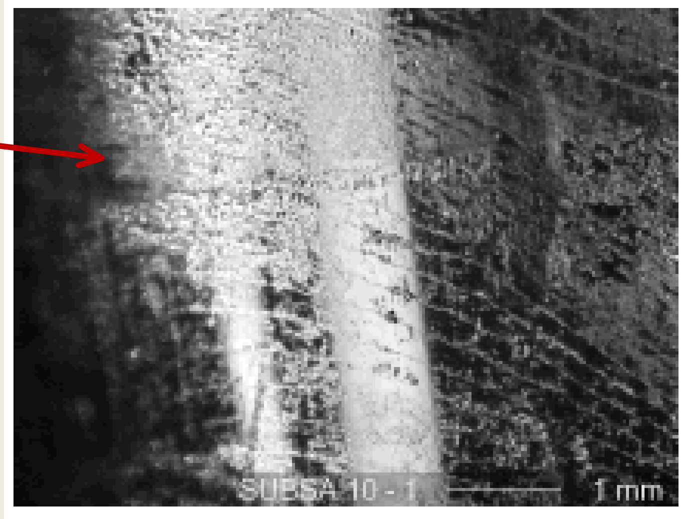


SUBSA-10



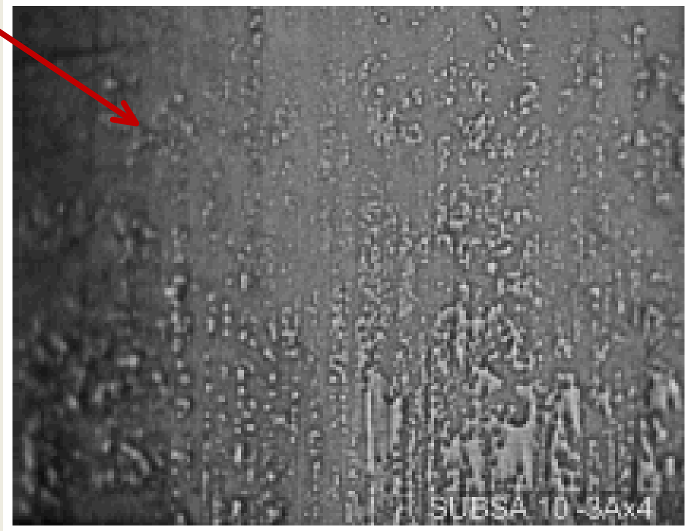
Surface Characteristics of SUBSA-10

Surface striations related to de-wetting with a discontinuous movement of the melt-crucible contact line



Partial de-wetting

Complete de-wetting



Conclusions

• Two samples, SUBSA-08 and SUBSA-09, grown with a carbon baffle, show absence of the diffusive initial transient

•SUBSA-10, grown without a carbon baffle, shows a short diffusion-controlled transient, in agreement with the Smith et al. equation.

• Partial de-wetting occurred in SUBSA-10, apparently disturbing the diffusive transport of Zn in the melt

•The appearance of partial dewetting in SUBSA-10 coincides with the departure from diffusion-controlled segregation

•An order of magnitude analysis shows that the thermocapillary convection on the meniscus surface leads to a melt velocity of ~ 2 cm/s.