EX18608 (京都大学推薦課題)

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Numerical simulation of InGaSb crystal growth under micro-gravity onboard the International Space Station

Introduction

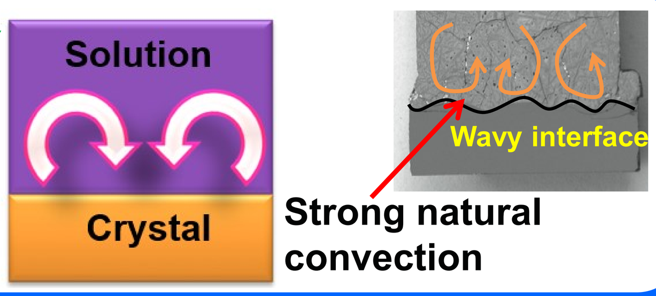
$In_xGa_{1-x}Sb$ promising semiconductor

Controllable lattice constant and wavelength

Required for many thermal-photo-voltaic devices

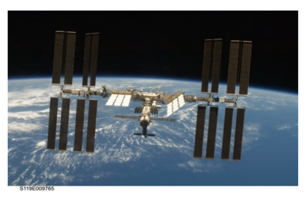
Normal gravity

Difficult for high-quality crystal growth On Earth



Microgravity environment

- Only diffusion effect
- Adverse effects minimized
- Better quality growth rate



International Space Station

10^{-4} G

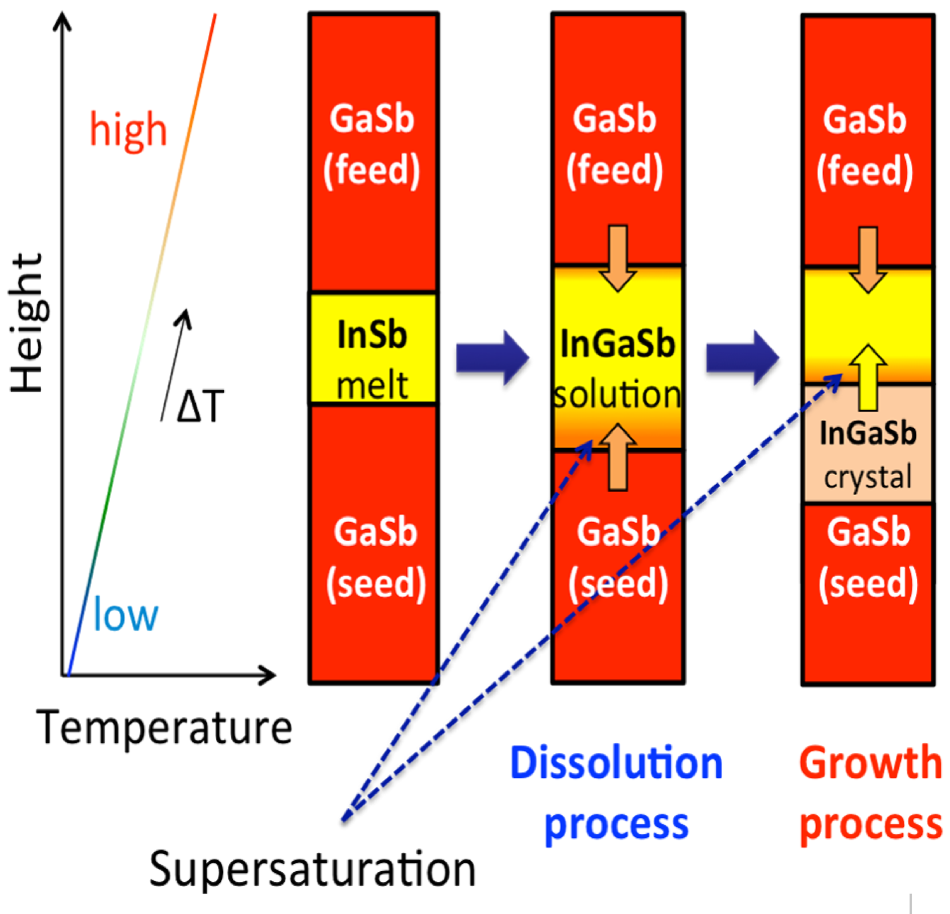
Objective

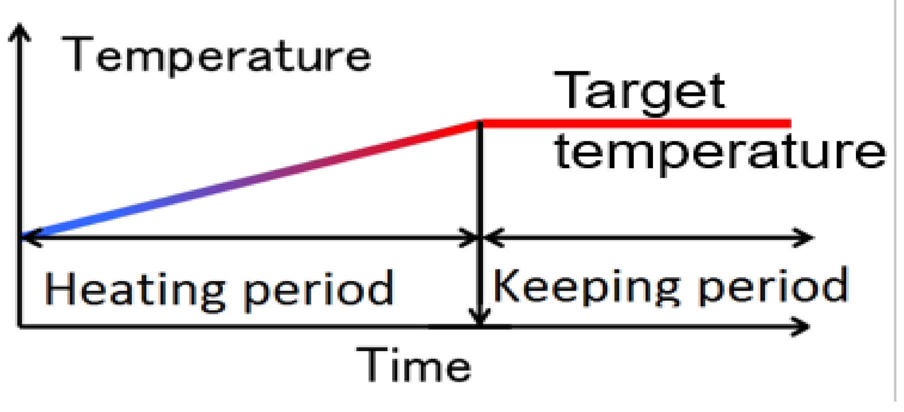
Develop a 2D-axisymmetric numerical model to investigate the dissolution/growth process of InGaSb in ISS

Conclusion

- A new 2D-axisymmetric numerical model has been developed.
- The heat flux on the bottom has no significant effect on the dissolution length of the seed crystal
- The final dissolution length and seed interface shape was determined by the temperature around the seed interface.

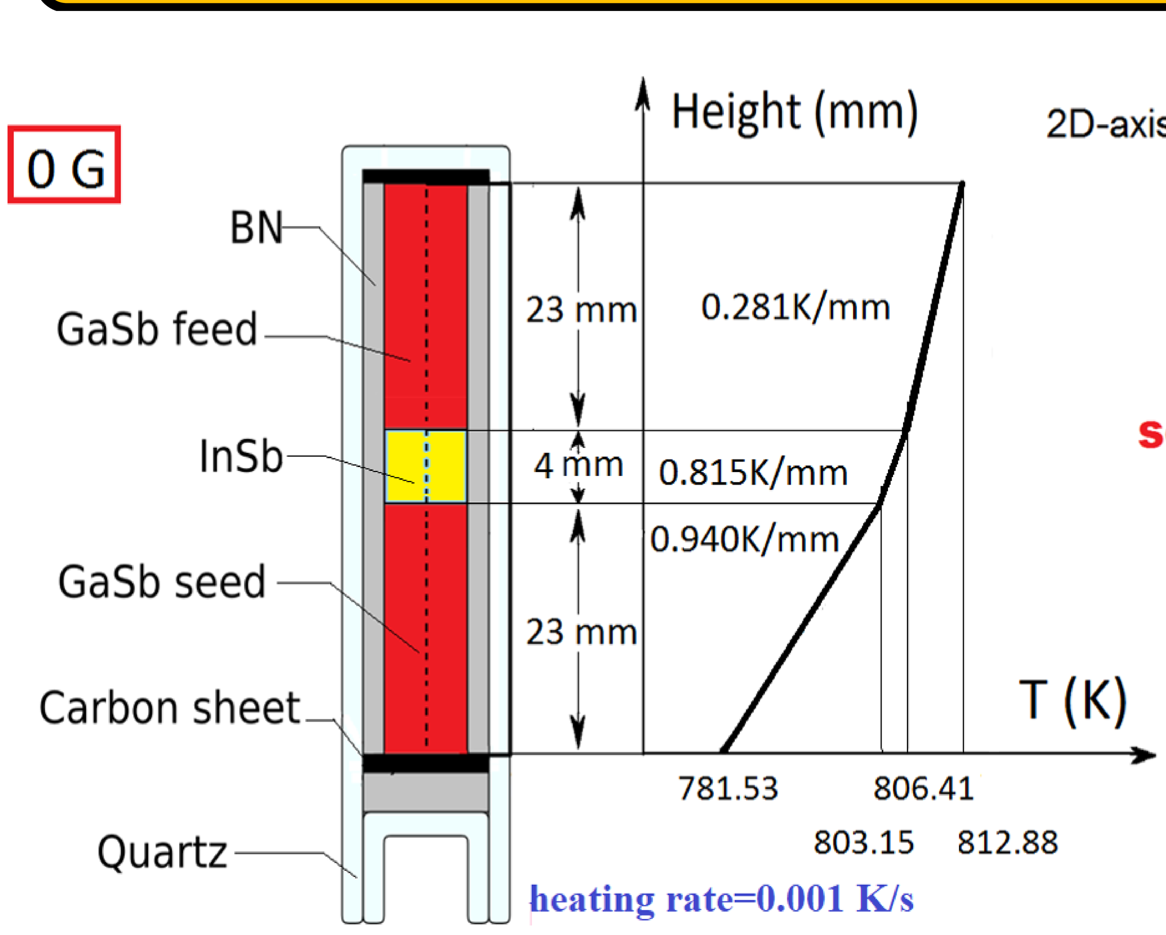
Temperature gradient method

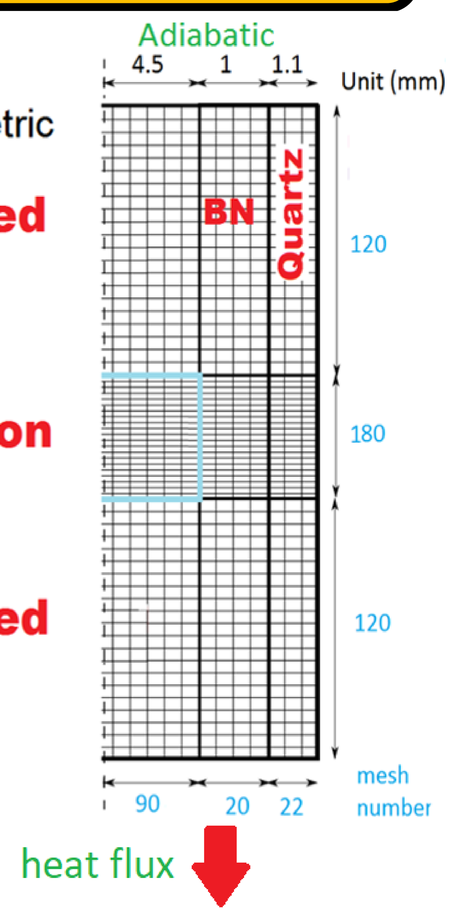




G. Rajesh *et al*., *J. Cryst. Growth*, **324** (2011) 157.

Numerical analysis





Case	Heat flux through bottom wall	Target temperature (heating time)
A (experiments setting)	Without (zero-gradient)	Original (6295.2 s)
B	With (1000K/m ▽T)	Original (6295.2 s)
C	With (1000K/m ▽T)	Original -3K (6175.2 s)
D	With (1000K/m ▽T)	Original -10K (5895.2 s)

Equations:

Heat conduction — **Solution**

$$\frac{\partial T}{\partial t} = \alpha_i \nabla^2 T \quad (i = L, S)$$

Mass transport:

$$\frac{\partial C}{\partial t} = D_i \nabla^2 C \quad (i = L, S)$$

Mass transport: — **BN Quartz**

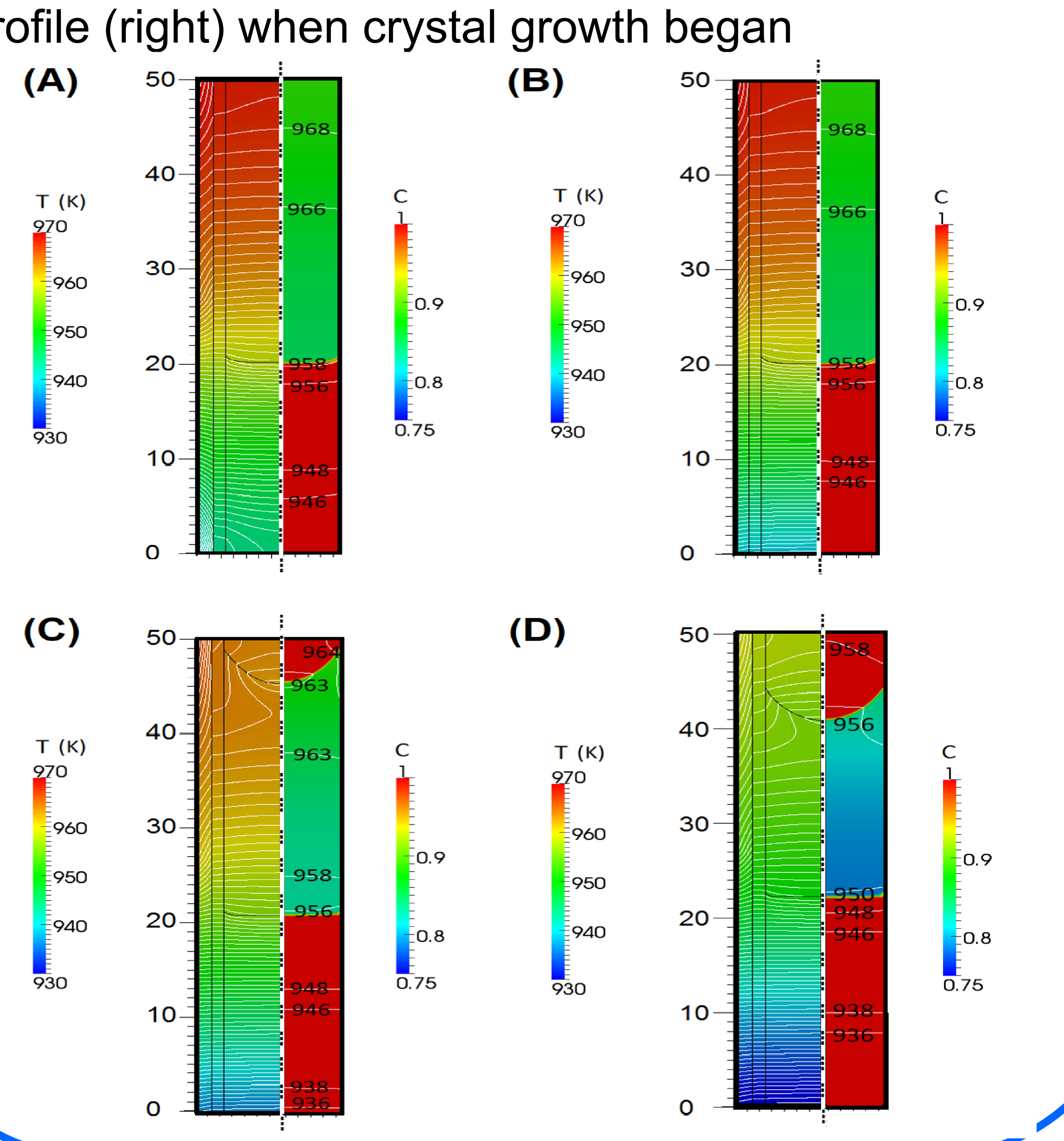
$$\frac{\partial T}{\partial t} = \alpha_i \nabla^2 T \quad (i = BN, Q)$$

To accelerate the calculation

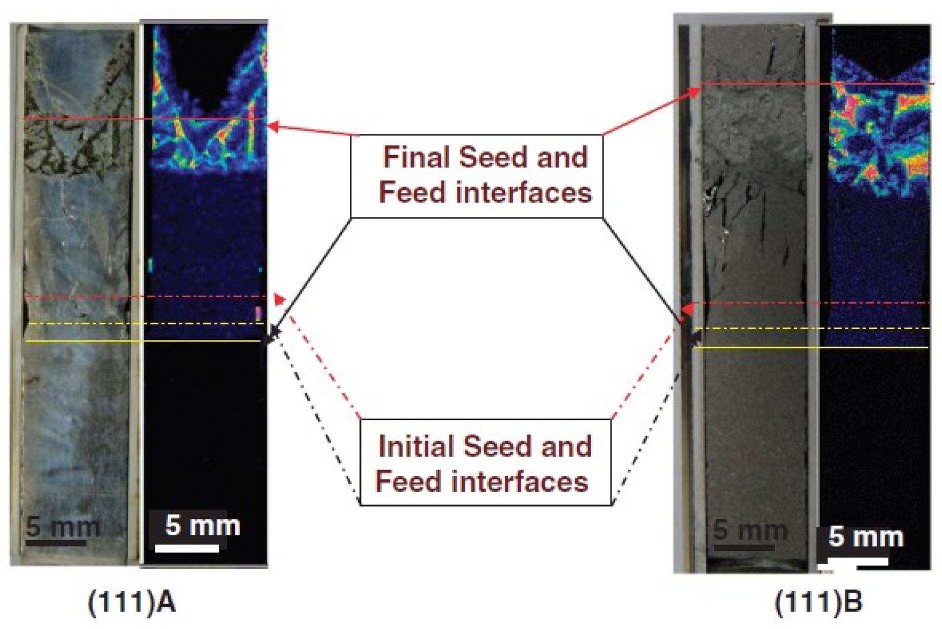
2D-axisymmetric mesh
Interface-capturing method
Under zero gravity
Solved by OpenFOAM

Numerical results

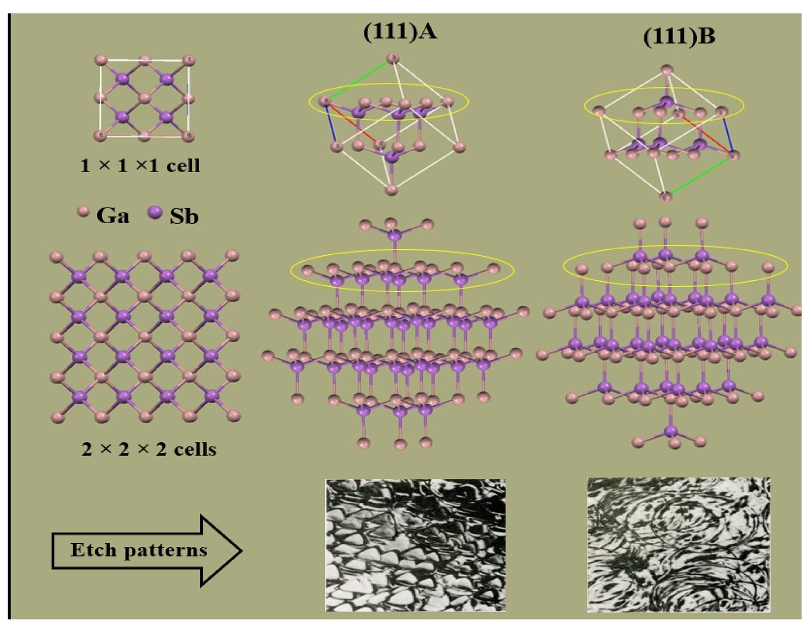
Temperature distribution (left), Ga concentration profile (right) when crystal growth began



Future work



Crystal grown in space: (111) A & (111) B



Crystal orientation

Growth/interfacial kinetics

Dissolution length & Growth rate

Y. Inatomi *et al*., *npj Microgravity*. **1** (2015) 15011
V. Nimral Kumar *et al*., *npj Microgravity*. **2** (2016) 16026
J. Xin *et al*., *Int. J. Microgravity Sci. Appl*., **34(2)** (2017) 340206.