Crystal Growth of Semiconductors in Microgravity

Rachel A. Taylor Literature Seminar October 3, 2002

Microgravity is a tool that allows investigation into better understanding crystal growth. By using a microgravity environment, macromolecular crystals and semiconductors can be grown.[1,2] The information gained from microgravity experiments can then be used to grow better crystals on earth.[3,4] Semiconductors are being studied because of their major importance in the electronics industry.

Detached growth, where the crystal grows without contact with the crucible walls, often occurs to semiconductor crystals grown in microgravity.[4-7] The lack of wall contact results in a crystal surface with no apparent relation to the surface state of the crucible. The overall shape of the crystal is still determined by the shape of the crucible however. The experiments are using the Bridgmen method to grow the single crystals.

When detached growth occurs, the quality of the crystal is improved; there are fewer dislocations, grains, and bubbles.[3, 8-11] For example, the surface of the detached areas of a germanium crystal are improved by having a smaller etch pit density than the attached portion as seen in the SEM images in Figure.[12] Although the mechanism for detached growth is not yet entirely understood, there are many important parameters that are thought to affect the process.[4-7] The crucible material determines the wetting angle while the meniscus formed during the process allows a curve-free surface on the semiconductor to develop.

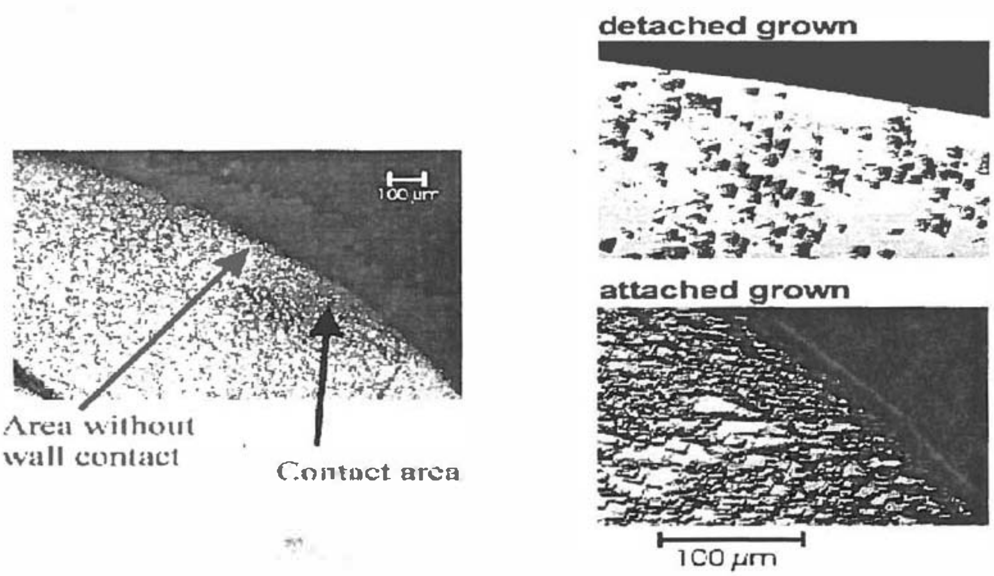

Figure 1

Increasing single crystal sizes is one area aided by microgravity. Gallium antimonide has a differential in crystal size when grown in 1g and μg environments (g being gravity).[13] On earth the GaSb crystal is about 7 mm in diameter while the crystal grown in space is 16 mm (Figure 2).[13]

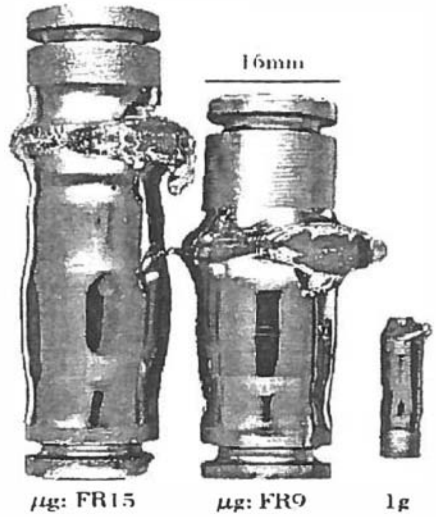

Figure 2

Since the crystals from microgravity grow with detached growth, the properties of the crystal are improved. One comparison of a GaAs Earth grown and a GaAs space grown crystal indicates an improvement in the space grown sample due to a decrease in dislocation density.[14] The decrease in the number of dislocations improves the conductivity of the crystal.[15] In another study, GaAs crystals from Earth and space were cut into wafers. The wafers were made into analog switch integrated circuits whose electrical properties of average threshold of backgating, photosensitivity, and average time of turn-on were tested; the tested properties of the space grown samples were found to be superior.[16]

Progress in microgravity research has been made, but there is still plenty of room for expansion in the field. There are few controlled experiments comparing earth and microgravity samples due to the fact that the technique most often has to be done in space adding large costs and giving limited facilities.[17] Despite the difficulties, microgravity experiments will continue to help further understand the crystal growth of semiconductors.

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