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Growth and defect characterization of SiC bulk crystals

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Beamline(s): X19C

Introduction: The silicon carbide (SiC) is a potential semiconductor material to replace and outperform the conventional silicon in several electronic devices for high power and high frequency and high temperature applications. However, at present, the material quality still remains an obstacle to a commercial outbreak of SiC technology. Improvement of the structural perfection and the increase in size of the SiC wafers are key areas of research and development in this field. Continued improvement in the quality of crystals obtained by the seeded sublimation growth technique known as "Modified Lely Method" is mainly due to the sustained research effort. The instrumentation and technology involved in the bulk growth of SiC are complex. There are some intrinsic growth related problems such as generation and propagation of hollow-core growth dislocations of large Buergers vector known as micropipes or super-screw dislocations, and inclusions of other polytypes. These defects are the limiting factors in the reliable device performance. Understanding of the origin these defects and optimization growth technology has become important in SiC technology.

Methods and Materials: A complete SiC PVT growth system has been designed and fabricated in the laboratory. It consists of 30 KW induction power supply, growth chamber incorporating the hot-zone and high vacuum system with provision for maintaining the pressure at any predecided value. The growth chamber is installed in horizontal configuration. The seed crystal was mounted on the lid of the graphite crucible. Growth was achieved at lower Ar pressure by the physical vapor transport induced by the temperature gradient. Crystals upto 2 inch diameter have been grown adopting a new seed mounting technology at crystal temperature 2100°C and Ar pressures at 30- 60 Torr with temperature differential (ΔT) 50-100°C. The c-face of the as grown crystals were studied under AFM in contact mode. The crystals were also studied using synchrotron white beam x-ray topography (SWBXT) and preferential chemical etching.

Results: AFM study on the as grown c-surface of SiC crystal clearly shows spirals and step flow pattern. Figure 1 shows a growth spiral, which is due screw dislocation with large Buergers vector. At the center of the spiral one can also observe an open-core. The diameter of the open-core is proportional to the magnitude of the Buergers vector. This screw dislocation mechanism is the predominant one in the growth of SiC crystal. Figure 2 is the back reflection synchrotron white beam x-ray topograph which shows large number micropipes and also other polytypes.

Conclusions: Single crystals of SiC have been grown by physical vapor transport. The AFM study clearly shows the screw dislocation mechanism operating on the growth of SiC crystals. The back reflection synchrotron topography also shows the micropipes running along the growth direction.

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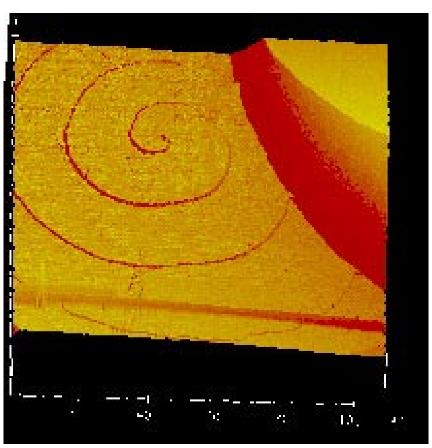

Figure 1. Growth spiral due to a screw dislocation.

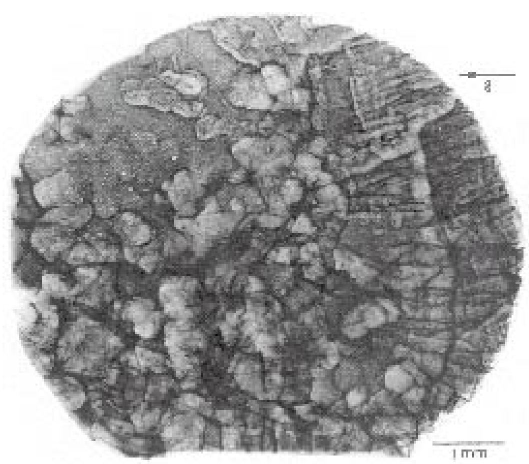

Figure 2. Back relection synchrotron white beam x-ray topography of the grown crystal.