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Nucleation of 3C-SiC During the Growth of Atomically Flat Mesas on 4H-SiC

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Beamline(s): X19C

Introduction: We recently reported the epitaxial growth of atomically flat mesas on (0001) 6H and 4H-SiC surfaces by promoting step-flow growth on SiC wafers which have previously had arrays of device-size mesas etched onto them [1]. Some of these mesas encompass the axial screw dislocations that typically occur scattered across the area of SiC semiconductor wafers. Here we study a non-optimal region of a 4H-SiC wafer that underwent this process and suffered nucleation of the both twins of the 3C polytype of SiC onto the 4H substrate.

Methods and Materials: Mesas ranging in size from a few tens of µm across to 400 µm x 400 µm squares were prepared on a nominally on-axis 4H-SiC wafer (which in this case means 0.4° with respect to (0001)). An abundance of step-free surfaces were obtained over the majority of the wafer. A piece from the edge region of the wafer containing atomically flat 4H-SiC mesas as well as mesas covered with 3C-SiC was selected for analysis by synchrotron white beam x-ray topography. Topographic images were recorded on Kodak Industrex SR-1 X-ray film at a specimen-to-film distance of 20cm in the back-reflection and low-angle reflection geometries. Detailed mapping of the distribution of the polytypes and their variants could be carried out by colorizing low-angle reflection topographs representing the 3C deposition on the wafers, then superimposing them on a back-reflection topograph that represented the 4C deposition on the wafer. Additionally, back-reflection topography mapped the distribution of axial screw dislocations across the area of the sample.

Results: Atomically flat mesas are expected to succeed only upon substrate mesas free of axial screw dislocations. After atomic flatness has been achieved, 2D nucleation of one of the 3C variants may occur on the mesa surface if the local supersaturation is conducive and the local terrace width broad enough. Which of two twinning variants of 3C nucleates will depend on the stacking sequence at the mesa's surface. On those mesas that contain screw dislocations, steps will be continuously regenerated from the growth spirals and atomic flatness will never be achieved, usually precluding 2D nucleation. However, 2D nucleation may occur on the broader terraces that might be produced further from the surface intersection point of the dislocations through interactions with step flow associated with the crystal offset angle. In such cases, nucleation of various mixtures of the two 3C variants would be expected depending on the local surface-terminating stacking sequence. As can be seen in figure 1, the supersaturation was not kept low enough to promote step-flow growth and avoid 2D nucleation of 3C-SiC.

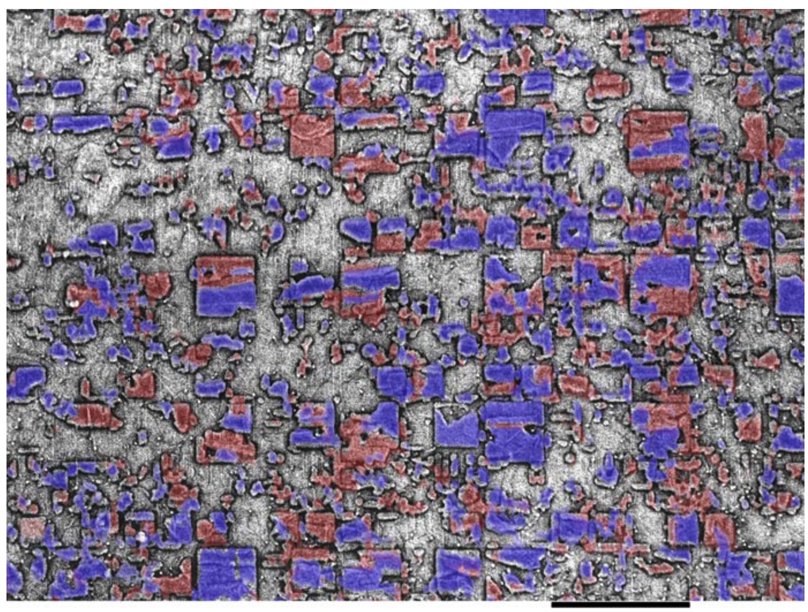

Figure 1. Polytype map formed by superimposing the 220 reflection from 3C(I)-SiC (blue) and the 113 reflection from 3C(II)-SiC (red) on the 00016 back-reflection image (gray). Small white circles in the back-reflection image are axial screw dislocations. Scale bar is 1mm.

Conclusions: Few of the numerous smaller, atomically flat mesas experienced 3C nucleation, expected since the probability of 2D nucleation of 3C is proportional to a mesa's surface area. In mesas containing screw dislocations, mostly those of larger size, either no 3C nucleation, or partial coverage by single or double phase 3C in areas removed from the screw dislocations occurred. Spiral steps generated from screw dislocations and steps associated with the crystal offset angle often led to the production of broad terraces far from the dislocation, upon which 2D nucleation of 3C could occur. This resulted in situations where islands of 4H encompassed the dislocation(s), with these islands being surrounded by a sea of 3C polytype.

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References:

[1]. J.A. Powell, P.G. Neudeck, A.J. Trunek, G.M. Beheim, L.G. Matus, R.W. Hoffman, Jr. and L.J. Keys, Appl. Phys. Lett., **77**, *1449*, 2000.