Application of Synchrotron X-ray Topography to Understanding Defect Behavior in Wide Band Gap Semiconductors

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A review will be presented of recent monochromatic and white beam synchrotron topography based studies of Physical Vapor Transport (PVT) grown 4H-SiC substrate boules and Chemical Vapor Deposition (CVD) grown 4H-SiC homo-epitaxial layers. The methodologies used in applying these techniques to determine the origins and evolution of the various defect structures in the boules and epilayers will be elucidated. In particular, criteria used in distinguishing grown-in from deformation induced defects will be discussed. Contrast observed from the various dislocations present in the crystals will be explained, and it will be shown how contrast simulation can be used to identify the detailed characteristics of the dislocations (for example, both Burgers vector sign and magnitude). Application of the various techniques to the complete analysis of the distribution, character and origins of grown-in c-axis screw dislocations, deformation induced basal plane dislocations (BPDs), and grown-in threading edge dislocations in PVT-grown substrates will be discussed. Formation of stacking faults will also be discussed. In addition, dislocation behavior during homo-epitaxy on offcut substrates will be presented. Studies carried out before and after epilayer growth have provided insight into the initial origins of the observed relaxation processes involving the creation of interfacial dislocations (IDs) and half loop arrays (HLAs). These processes are initially driven by thermal stress resulting from radial temperature gradients experienced by the wafer whilst in the epi-chamber. These processes provide screw oriented segments that pierce the advancing epilayer surface that initially replicate as the crystal grows. Once critical thickness is reached these screw segments glide sideways under mismatch induced stress leaving IDs and HLAs in their wake. The origin of the mismatch stress is shown to be associated with doping induced lattice parameter differences at the growth temperature. Prospects at advanced synchrotron sources for *in situ* studies of relaxation of epilayers will be discussed as well as *in operando* studies of device failure.