Materials Science and Engineering Doctoral Defense

Characterization of HgCdTe and Related Materials For Third Generation Infrared Detectors

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abstract

Hg1-xCdxTe (MCT) has historically been the primary material used for infrared detectors. Recently, alternative substrates for MCT growth such as Si, as well as alternative infrared materials such as Hg1-xCdxSe, have been explored. This dissertation involves characterization of Hg-based infrared materials for third generation of infrared detectors using a wide range of transmission electron microscopy (TEM) techniques.A microstructural study on HgCdTe/CdTe heterostructures grown by MBE on Si (211) substrates showed a thin ZnTe layer grown between CdTe and Si to mediate the large lattice mismatch of 19.5%. Observations showed large dislocation densities at the CdTe/ZnTe/Si (211) interfaces, which dropped off rapidly away from the interface. Growth of a thin HgTe buffer layer between HgCdTe and CdTe layers seemed to improve the HgCdTe layer quality by blocking some defects. A second study investigated the correlation of etch pits and dislocations in as-grown and thermal-cycle-annealed (TCA) HgCdTe (211) films. For as-grown samples, pits with triangular and fish-eye shapes were associated with Frank partial and perfect dislocations, respectively. Skew pits were determined to have a more complex nature. TCA reduced the etch-pit density by 72%. Although TCA processing eliminated the fish-eye pits, dislocations reappeared in shorter segments in the TCA samples. Large pits were observed in both as-grown and TCA samples, but the nature of any defects associated with these pits in the as-grown samples is unclear.Microstructural studies of HgCdSe revealed large dislocation density at ZnTe/Si(211) interfaces, which dropped off markedly with ZnTe thickness. Atomic-resolution STEM images showed that the large lattice mismatch at the ZnTe/Si interface was accommodated through {111}-type stacking faults. A detailed analysis showed that the stacking faults were inclined at angles of 19.5 and 90 degrees at both ZnTe/Si and HgCdSe/ZnTe interfaces. These stacking faults were associated with Shockley and Frank partial dislocations, respectively. Initial attempts to delineate individual dislocations by chemical etching revealed that while the etchants successfully attacked defective areas, many defects in close proximity to the pits were unaffected.

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