Generation and Expansion of Stacking Faults in Physical Vapor Transport grown 4H-SiC Single-crystals

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Physical vapor transport (PVT) technology has been successfully utilized in the commercialized growth of 4H-SiC single-crystal boules [1]. In this work, we investigate the generation and expansion of stacking faults (SFs) during the PVT growth of 4H-SiC single-crystals by combining the chemical etching and micro-structural observations. By combining molten-KOH etching and photo-chemical etching, we successfully reveal etch pits of TDs and linear etch patterns of SFs on the $(11\bar{2}0)$ surface of 4H-SiC single crystals [Fig. 1 (a)]. Systematic investigations based on transmission electron microscopy (TEM) observations and Raman analysis indicate that the Si-C bilayer stacking sequences of SFs are (3, 2) and (3, 3) in the Zhdanov's notation. As the PVT growth proceeds, SFs (3, 2) and (3, 3) tend to evolve into 6H-SiC and 15R-SiC, respectively. Interestingly, we find that the facet region of the 4H-SiC single-crystal boule is free of SFs (3, 3). Most of the SFs (3, 3) are constrained in the non-faceted region of 4H-SiC, because the shear stress in the facet region of a PVT-grown 4H-SiC single crystal boule is nearly zero, which eliminates the generation and expansion of SFs (3, 3) in the 4H-SiC single crystal boule [Fig. 1 (b)-(d)] [2].

For SFs (3, 2), the accumulation of SFs (3, 2) gives rise to the polymorph fluctuation, and thus the formation of 15R-SiC at the early PVT-growth stage of 4H-SiC single crystals. Quantitative stress analyses indicate that the strain-field distributions along the SFs (3, 2) and the 15R-/4H-SiC interfaces are inhomogeneous, which gives rise to the nucleation of TDs and low angle grain boundaries (LAGBs) locating at SFs (3, 2) and 15R-/4H-SiC interface, respectively. The nucleation of LAGBs release the high stress at the 15R-/4H-SiC interface, which facilities the following 4H-SiC single-crystal growth. Our work indicates that the avoidance of polymorph fluctuation is key to the reduction of SFs and TDs at the early growth stage of PVT-grown 4H-SiC single crystals [Fig. 1 (e)-(h)] [3].

References

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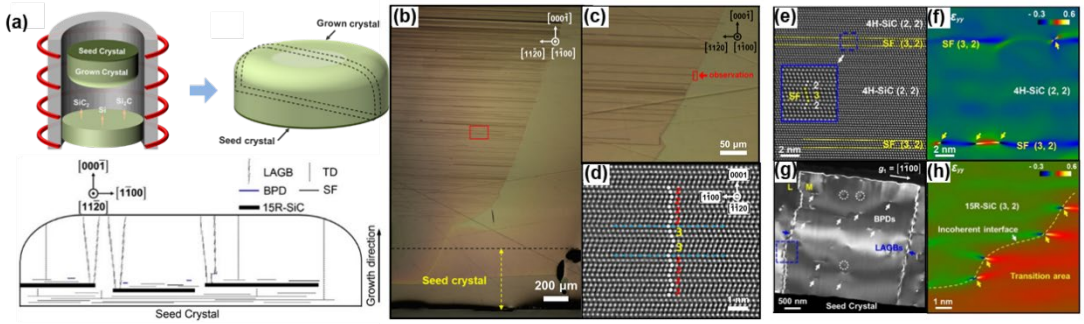

Fig. 1 (a) PVT growth, the vertical slicing and etching of 4H-SiC. Distribution of (b)-(d) SF (3, 3) and (e)-(h) SF (3, 2) in PVT-grown 4H-SiC single crystal.