Macrostep flow behavior in 4H-SiC solution growth with different solvent compositions and surface orientations

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In SiC solution growth, the conversion of threading screw dislocations to the defects on basal planes has been reported [1-3]. This phenomenon attracts attention as a growth mechanism to obtain high quality 4H-SiC. Since the TSD conversion occurs through the interaction between macrostep-flow and TSDs, the conversion efficiency depends on the structural features of macrosteps, such as the height and slope angle of macrosteps. In addition to the macrostep structure, the advancing speed of macrostep is another important factor for the TSD conversion because the speed determines the number of times the macrostep sweeps TSDs.

In this study, we have investigated the macrostep behavior during solution growth with various solvent compositions. The as-grown surfaces of crystals grown with Si, Si-5at.%Ti and Si-5at.%Al solvents are shown in the left-hand side of Fig. 1. It has been reported that addition of Al suppresses step-bunching [4]. On the other hand, addition of Ti enhances step-bunching and consequently improves the TSD conversion efficiency [5]. The cross-sectional micrographs on the right-hand side of Fig. 1 show bright linear contrasts corresponding to the traces of macrosteps. The contrasts arise from the difference in nitrogen concentration because the incorporation ratio on the slope of a macrostep is lower than that on macroterraces [6]. The linear contrast with shallow angles θ indicates the fast lateral advancing speed of the macrostep because the vertical growth rates are almost identical for the three growth conditions. Addition of Ti clearly enhanced the lateral advancing speed even though the macrosteps developed significantly. The effect of solvent compositions and surface polarity on the macrostep advance will be discussed in the presentation.

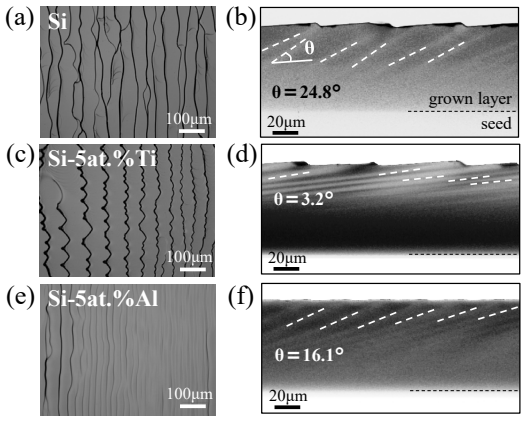

Fig. 1: Optical micrographs of the as-grown (000-1) surfaces (a, c, e) and transmission optical micrograph of the cross-sections (b, d, f) of 4H-SiC crystals grown with Si, Si-5at.%Ti and Si-5at.%Al solvents on 4 degree off (000-1) seeds. The white lines indicate the traces of macrostep flow. The angle θ was measured from the (000-1) plane.

Part of this work was supported by JSPS KAKENHI (JP22H01977), and part of the research was conducted in the Tsukuba Power Electronics Constellation (TPEC).

References

[1] T. Ujihara et al., Mater. Sci. Forum **717–720**, 351 (2012).
[2] Y. Yamamoto et al., Appl. Phys. Express **5**, 115501 (2012).
[3] S. Harada et al., APL Mater. **1**, 022109 (2013).
[4] T. Mitani et al., J. Cryst. Growth **423**, 45 (2015).
[5] S. Xiao et al., Cryst. Growth Des. **16**, 6436 (2016).
[6] T. Mitani et al., J. Cryst. Growth **568–569**, 126189 (2021).