Observations of Screw Dislocation Driven Growth and Faceting During CVD Homoepitaxy on 4H-SiC On-Axis Mesa Arrays

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Abstract (STRICLTY LIMITED TO 150 WORDS)

Previous studies of (0001) homoepitaxial growth carried out on arrays of small-area mesas etched into on-axis 4H-SiC wafers indicate that spiral growth emanating from at least one screw dislocation threading the mesa is necessary in order for a mesa to grow taller in the <0001> (c-axis vertical) direction while maintaining the 4H stacking sequence. However, even amongst mesas containing a screw dislocation spiral step source necessary for c-axis growth, we have observed significant differences in the height and faceting that evolve during prolonged homoepitaxial growths. This paper summarizes AFM, ECCI, SEM, and optical microscopy evidence that the observed large variation in growth behavior is related to the lateral position of a screw dislocation step source within the mesa. When the screw dislocation step source is located close enough to the edge/sidewall facet of a mesa, the c-axis growth rate and side facet slope are affected by the resulting interaction.

EXTENDED ABSTRACT

Previous studies of (0001) homoepitaxial growth carried out on arrays of small-area mesas etched into on-axis silicon-face 4H-SiC wafers have demonstrated that spiral growth emanating from at least one screw dislocation threading the mesa is necessary in order for a mesa to grow taller in the <0001> (c-axis vertical) direction while maintaining 4H stacking sequence [1]. However, even amongst mesas containing the screw dislocation step source necessary for vertical c-axis growth, we have observed striking differences in the height and faceting that evolve during prolonged homoepitaxial growths. This paper summarizes Atomic Force Microscopy (AFM), Electron Channeling Contrast Imaging (ECCI), Scanning Electron Microscopy (SEM), and optical microscopy observations of this phenomenon. These observations support our initially proposed model [2] that the observed large variation (for mesas where 3C-SiC nucleation has not occurred) is related to the lateral positioning of a screw dislocation step source within each etched mesa. When the screw dislocation step source is located close enough to the developing edge/sidewall facet of a mesa, the c-axis growth rate and facet angle are affected by the resulting interaction. In particular, the intersection (or near intersection) of the inward-sloping mesa sidewall facet with the screw dislocation appears to impede the rate at which the spiral provides new steps required for c-axis growth. Also, the inward slope of the sidewall facet during growth (relative to other sidewalls of the same mesa not near the screw dislocation) seems to be impeded by the screw dislocation. In contrast, mesas whose screw dislocations are centrally located grow vertically, but inward sloping sidewall facets shrink the area of the top (0001) growth surface almost to the point of vanishing.

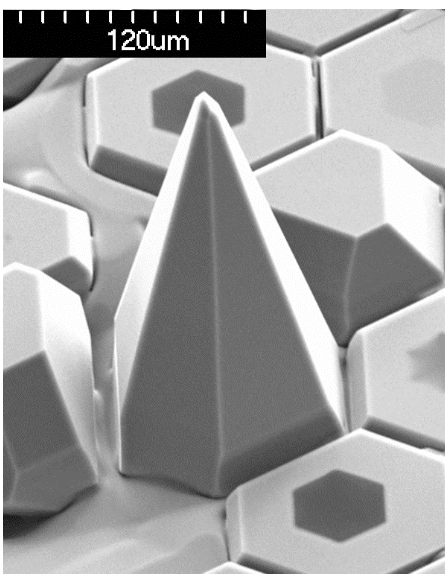

Fig. 1. Faceted vertical growth via 4H-SiC CVD homoeptiaxy enabled by a screw dislocation located in the middle of a mesa. Note that other nearby mesas, which started with identical hollow hexagonal pre-growth shapes, exhibited much less vertical growth.

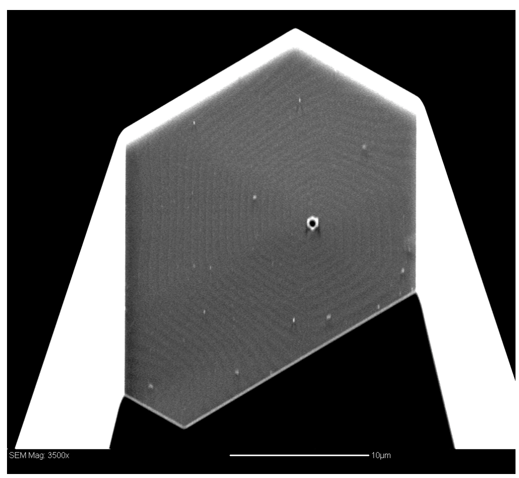

Fig. 2. ECCI image revealing screw dislocation spiral steps imaged on the small top (0001) surface of a mesa that exhibited tall faceted growth similar to the tall mesa shown in Fig. 1. Scale marker line at bottom is 10um.

[1] P. Neudeck et al., Chemical Vapor Deposition, Vol. 12, p. 531 (2006).
[2] Y. Picard et al., MRS Symp. Proc. Vol. 1069, p. 151 (2008).