Vapor-Liquid-Solid Growth: Twins and Droplet Stability

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During vapor-liquid-solid (VLS) growth of nanowires, molecules from the vapor contact a liquid catalyst, decompose, and feed the growth of the solid wire. This yields wires that are of nanometers diameter and microns length. A twin-plane based nanowire growth mechanism is established using Au catalyzed Ge nanowire growth as a model system. Video-rate lattice-resolved environmental transmission electron microscopy shows a convex, V-shaped liquid catalyst-nanowire growth interface for a <112> growth direction, that is composed of two Ge {111} planes which meet at a twin boundary, see Figure 1. Unlike to bulk crystals, the nanowire geometry allows steady state growth with a *single* twin boundary at the nanowire center. We suggest that the nucleation barrier at the twin-plane re-entrant groove is effectively reduced by the line energy, and hence the twin acts as a preferential nucleation site that dictates the lateral step flow cycle that constitutes nanowire growth. It is well known that the morphology of nanowires grown using the VLS mechanism depends substantially on the stability and configuration of the catalyst droplet. Whereas many of the earlier studies have focused on the conditions under which the liquid droplet remains stable [1-3], here we enquire as to what happens if and when the liquid droplet unpins from the corner. We employ a perturbation approach and arrive at the fact that there is a much larger tendency for the liquid droplet to unpin in an asymmetric manner than in a symmetric manner even in the absence of any underlying geometric asymmetry or anisotropy. The implications of this to a number of experimental observations are discussed.

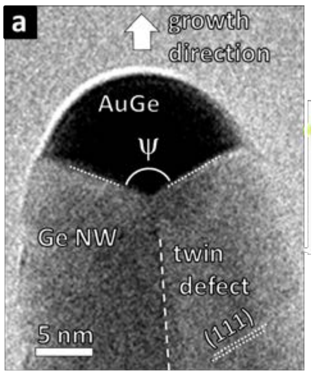

Figure 1 Twinned V-shaped interface in a [112]-type Ge NW growing from a liquid catalyst at 341 °C. The angle ψ measures ≈ 131±2°. The location of the twin defect and liquid-solid interface are indicated by the dashed and dotted white lines, respectively.

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