Analysis of Ridges and side facets during Czochralski crystal growth

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The geometry of single crystals grown *via* meniscus-defined methods can be significantly influenced by the combined effect of anisotropy in interface attachment kinetics and capillarity. We are specifically interested in how relevant material properties and operating conditions influence the appearance of ridges and side facets in Czochralski (CZ) growth systems. These geometric features have been described and analyzed in the past, especially for the case of dislocation-free silicon grown (via the CZ method) in the [001] direction. Voronkov (e.g. [1-3]) provided significant theoretical insight into the formation of ridges and side facets, which for this specific case ([001] direction CZ silicon), are associated with {111} facet planes appearing on the melt/crystal interface. Later, numerical studies [4,5] have shown a certain ability to predict ridge shapes which, in some cases, were compared to experimental data. A more recent effort involving Voronkov's theory (with and without important modifications), combined with experiments [6,7], was focused on recovering important information based on experimental studies, as well as accounting for dynamics at the triple phase line.

In this contribution we will review the status of the relevant theory after which we will present 3D numerical calculations of CZ growth exhibiting side facets, ridges and transitions between these two features. Sensitivities to details of growth angle anisotropy, as well as other system operating conditions, will be analyzed and discussed in relation to previous studies.

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