Dislocation Interaction with Faceted Groove at Grain Boundary in Multicrystalline Silicon

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Introduction
The quality of multicrystalline silicon (mc-Si) is significantly affected by grain boundaries which, in turn, are largely influenced by the groove behaviors, that therefore are important to be understood.
Experimental
An in situ observation containing a high speed microscope and a crystallization furnace, as well as the EBSD analysis method, were used to study the morphology of the crystal/melt interface during the solidification process and the crystallographic orientations of the sample surfaces after the solidification process.
Results
Firstly, during the development of a small angle grain boundary (SAGB), a groove appeared. Without apparent external perturbation at the groove, an increase of the facet sizes was observed (Fig.1(a)). The travelling distance of the grain boundary until the facet size stopped growing is similar to the calculated travelling distance according to the 2D facet nucleation theory[1]. However, the facet sizes measured during the experiment, as well as the undercooling at the groove, are smaller than the calculated ones. This suggests that the 2D growth theory is not totally representative of growth behavior.
Secondly, perturbations at the groove with sudden changes of the grain boundary direction were observed later at the same groove (Fig.1(b)). The growth velocity of the facets was measured from the in situ video, which shows that there was a sudden acceleration of one facet growth when the perturbations happened at the groove. In addition, the SEM observation of the Sopori-etched sample shows that there were dislocations at the sample surface. Therefore, we suppose that the perturbation was caused by the dislocation interaction with the facet, which changes the facet growth law from 2D to dislocation driven theory according to Voronkov [2]. Then, a geometrical model was created to calculate the perturbation at the groove, when a facet grows with a dislocation interaction. The calculated outline of the perturbed groove as well as the grain boundary structure were comparable to the experimental observation when continuous dislocations interacted with the facet on one side at intervals,. However, the growth rate of the other facet without apparent dislocation interaction slowed down, which is opposite to the experimental results. Therefore, further experiments and a more accurate model are needed.

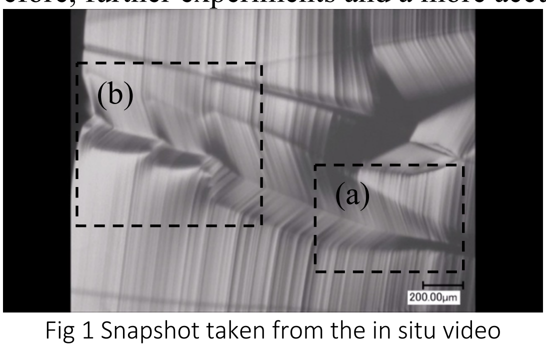

Fig 1 Snapshot taken from the in situ video

[1] Fabiyi et al. Journal of Crystal Growth 592(2022) 126736.
[2] Voronkov V.V., Sov. Phy. Crystallogr. 17 (1973), pp. 807-813.