A New Model for Intrinsic Point Defects in Silicon Crystals grown from the Melt: Proof by X-Ray Diffraction Topography

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There has been no procedure reported for direct observation of vacancies and silicon interstitials. However, by nature these defects tend to aggregate to form secondary defects, such as voids and interstitial type dislocation loops. They can be observed by TEM and by an optical microscope as etch pit such as the flow pattern defects (FPD) and the Secco etch pit defects (SEPD). However, it is necessary to observe the macroscopic distributions of secondary defects for a deeper understanding of the generation and the annihilation of point defects. The combinations of strain-sensitive X-ray topography with copper decoration in FZ crystals which is shown in Fig. 1 as a typical example and anomalous oxygen precipitation (AOP) with interactions between vacancies and interstitial oxygen atoms in CZ crystals have provided the experimental insight required for a unified and global understanding of defect behavior.

Almost all on intrinsic point defects have postulated the coexistence of vacancies and silicon interstitials near the growth interface. It is generally considered that in the vicinity of interface vacancies are abundant species and move slowly, while interstitials are rare species and move fast. On this basis, people tried to construct the formation mechanisms of secondary defects such as A- and D- defects. Recently, we have established by experiment and theory that the temperature gradient at the growth interface decreases as the pulling velocity increases, and vice verse. The impact of this observation on the formation mechanism of secondary defects is not small, because the most important part of formation of secondary defects occurs at that region. Thermal stresses induced by the temperature gradient could influence on the formation of defects. This effect has not, so far, been considered seriously. In particular, this is true by considering that thermal stress is favorable for formation of interstitial. On the other hand, there is evidence that an enough amount of vacancies are always present just at the interface. Only when the temperature gradient is large enough (this is the condition for slow growth rate), I(silicon interstitial)-rich regions can be formed by overcompensating the pre-existing vacancies by an enough amount of interstitials. These are derived by our observation on the kinetics of reaction between defects by changing the growth rates.

References:

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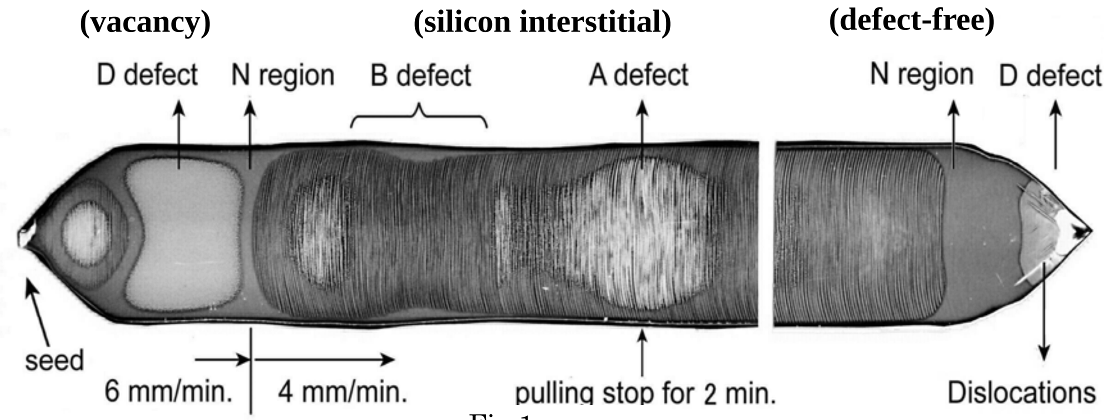

Fig.1

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