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太陽電池用多結晶シリコン[001]、[111]面結晶成長における冷却速度と転位伝播におけるスリップシステムの活性化との関係

Relationship between cooling rate and activation of different slip system under [001] and [111] growth for multicrystalline silicon growth for solar cell

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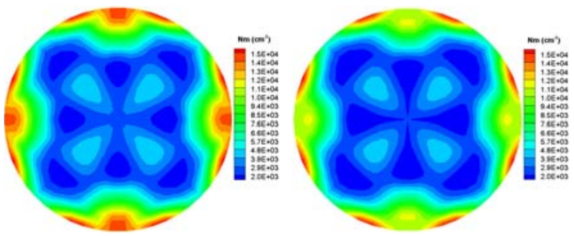
Introduction

The dislocations generated during the growth of multicrystalline silicon in a unidirectional solidification furnace can greatly degrade the electronic properties of the grown materials. The presence of dislocations has been mainly attributed to bulk single growth and ingot cooling process. The ingot cooling process can cause the dislocation density to rapidly increase. The rapid increase of the dislocation density is due to the activation of several slip directions by resolved shear stress. In order to understand the increase mechanics of dislocation density under different cooling rate, it is essential to analyze the relationship between cooling rate and activation of different slip systems under different growth direction.

Calculation method

Alexander and Haasen mode is extended to a multi-axis stress state. The generation of dislocation is attributed to the slip on 12 possible slip directions and the cross-slip between different slip systems; the immobilization of mobile dislocation and the annihilation of dislocation are also included.



(a)　(b)

Fig. 1. Comparison of dislocation density distribution of one (001) slice under [001] growth direction for (a) fast cooling rate, (b) slow cooling

Results

Fig. 1 gives a comparison of dislocation density for fast cooling and slow cooling rates on one (001) slice under [001] growth direction. Slow cooling rate (Fig. 1(b) activates eight slip directions, which causes an eight-fold symmetric distribution; however, fast cooling rate activates extra four slip directions, which superposes an extra four-fold symmetric structure upon the slow cooling rate case. Therefore, fast cooling rate activates all of slip directions and the slow cooling only activates eight slip directions. The residual stress due to fast cooling and slow cooling is also examined.