

Behavior of particle depots in molten silicon during float-zone growth in strong static magnetic fields

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In the photovoltaics industry, the largest market share is represented by solar cells made from multi-crystalline silicon, which is grown by directional solidification. During the growth process, the silicon melt is in contact with the silicon nitride coated crucible walls and the furnace atmosphere which contains carbon monoxide. The dissolution of the crucible coating, the carbon bearing gas, and the carbon already present in the feedstock, lead to the precipitation of silicon carbide, and silicon nitride, at later stages of the growth process. The precipitation of Si_3N_4 and SiC particles of up to several hundred micrometers in diameter leads to severe problems during the wire sawing process for wafering the ingots. Furthermore the growth of the silicon grains can be negatively influenced by the presence of particles, which act as nucleation sources and lead to a grit structure of small grains and are sources for dislocations. If doped with Nitrogen from the dissolved crucible coating, SiC is a semi conductive material, and can act as a shunt, short circuiting parts of the solar cell. For these reasons, the incorporation of such particles needs to be avoided.

In this contribution we performed model experiments in which the transport of intentionally added SiC particles and their interaction with the solid-liquid interface during float zone growth of silicon in strong steady magnetic fields was investigated. SiC particles of $7\mu\text{m}$ and $60\mu\text{m}$ size are placed in single crystal silicon [100] and [111] rods of 8mm diameter. This is achieved by drilling a hole of 2mm diameter, filling in the particles and closing the hole by melting the surface of the rod until a film of silicon covers the hole. The samples are processed under a vacuum of $1 \cdot 10^{-5}$ mbar or better, to prevent gas inclusions. An oxide layer to suppress Marangoni convection is applied by wet oxidation. Experiments without and with static magnetic field are carried out to investigate the influence of melt convection on the distribution of particles and their incorporation into the crystal. The field strengths applied by a superconducting magnet are 1T, 3T, 4.5T, and 5T. The increase in field strength dampens the melt flow, and so this study provides comparative data to the crystal growth experiment to be carried out onboard the sounding rocket mission TEXUS 51, where purely diffusive growth condition will be achieved under microgravity conditions.