NUMERICAL SIMULATION OF SILICON CRYSTAL GROWTH PROCESS FOR PV APPLICATIONS

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ABSTRACT

The photovoltaic (PV) system installation is booming since 2010. The large-scale PV generation costs already compare with conventional electricity production today. One of major contributions is due to the development of the silicon growth techniques, which are able to produce the high quality and low cost silicon wafer of solar cells. This lecture will provide some perspectives on how numerical simulation has been used to improve the crystal growth process. Two main crystal growth methods are investigated: Czochralski (CZ) and Directional Solidification (DS). The CZ method is commonly used in industry for producing the mono silicon crystal for p- and n-type solar cells, while the DS one is widely adopted for manufacturing the multicrystalline silicon ingot for p-type solar cells. The oxygen impurities can be incorporated into the mono silicon crystal during the CZ process leading to degeneration in the performance of p-type mono-crystallization silicon solar cells. Through the numerical simulation, we are able to understand the transport mechanisms of oxygen impurities during the CZ growth process and achieve the low and homogeneous oxygen concentration in the silicon crystal by adjusting the furnace structure and the operational parameters during the growth process. On the other hand, the challenge of the DS method is how to grow larger ingot with higher yield and quality. To achieve this goal, the slightly convex shape of melt-solid interface during the seeded DS growth process is required. The best melt-crystal interface shape for growing the 850 kg silicon ingot can be attained by the suitable modification of furnace structure. The efficiency of p-type multicrystalline silicon solar cell made from these DS wafers is higher than 19%.

KEYWORDS: Silicon Solar Cells, numerical simulation, Czochralski Crystal Growth, Directional Solidification Growth