Optimization of thermal field for 8-inch 4H-SiC single crystal grown by PVT method

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Silicon carbide (SiC) is positioned as a front-runner semiconductor for the next-generation of power devices and suitable for application in the high-power, high-frequency and high-temperature fields, due to the superior physical properties. Most of the commercially available 4H-SiC substrates with 4, 6-inch in diameter are prepared by physical vapor transport (PVT) method and then used to fabricated the SiC power devices with higher operating efficiency. However, the power semiconductor market has always been dominated by Si-based devices and the market penetration of SiC devices is still relatively low, which is largely due to the high market price of SiC. Generally, for 6-inch wafer, the price of SiC is 5~6 times that of Si. Therefore, the key to expand the application of downstream industries is to reduce the cost of SiC crystal preparation. Increasing the diameter of ingot is a mainstream direction to solve the mentioned issue and has attracted the attention of many researchers in the field. Unlike the melt method, it is extremely difficult to obtain the large-size SiC single crystal via PVT method due to the large temperature difference in radial direction of growth interface as using large-sized crucible, and resulting in too convex shape in crystal ingot, which will seriously deteriorate grown crystal. Therefore, design and optimization of thermal filed is crucial on larger-sized SiC crystal growth and to form an appropriate axial temperature gradient to maintain the driving force for crystal growth, while obtaining the radial temperature uniformity of thermal field to improve crystal quality.

In this study, the influence of crucible structure on the thermal field distribution was investigated by VR-PVT software and then the optimal thermal field conditions were carried out in the experiment and successfully obtained 8-inch 4H-SiC crystal, as shown in Fig. 1.

Fig. 1. Optical photos of 8-inch SiC ingot with a thickness of 40 mm