機械学習モデルを援用した 150 mm SiC 溶液成長
Solution growth of 150 mm SiC under the guidance of machine learning

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Silicon Carbide (SiC) is a leading choice among semiconductors for high-power and high-efficiency devices. Nowadays, top-seed solution growth (TSSG) method has attracted an increasing amount of attention as it can reduce the threading dislocation density in SiC crystal by a high-efficiency dislocation conversion mechanism.[1] In this paper, 150 mm (6-inch) SiC crystals was fabricated by TSSG technique with the guidance of machine learning. It is conceivable that this method has great potential in promoting the development of all crystal materials.

To develop the crystal growth technique, many parameters should be optimized simultaneously, consuming much time and funds. Consequently, machine learning technique, including neural network (NN) and genetic algorithm (GA), was induced to accelerate the developing of crystal growth [2]. NN is built to obtain the heat transfer, carbon mass transport and convection in solution at a prediction speed 10^7 times faster than that of common computational fluid dynamics simulation [3]. Then GA optimization was utilized to reveal the optimal parameters for SiC growth automatically. Standard deviation of growth rate, temperature on seed surface and temperature at crucible side wall are set as the objective functions in GA process to achieve high-quality long-term growth.

By utilizing the machine learning method, global optimization among all possible solutions can be obtained with several optimal solutions supplied as shown in Figure 1. Preponderant condition for actual crystal growth experiments were chosen from the possible candidates by human decision making. Commercial 150 mm 4H-SiC substrates with 4 ° off [0001]-oriented were used as seed crystals. The photograph of the as-grown crystal is shown in Figure 2, exhibiting a uniform smooth surface. The successful fabrication of 150 mm SiC crystal indicates the validity of this method.

We sought to develop a method to promote the development of crystal growth. The machine learning technique was adopted to find out the optimal configuration from all possible conditions for crystal growth in a short time. Under the guidance of machine learning, 150 mm 4H-SiC crystal was grown in reality by top-seed solution growth method. The machine learning technique represents an innovative and attractive strategy in the development of crystal growth.
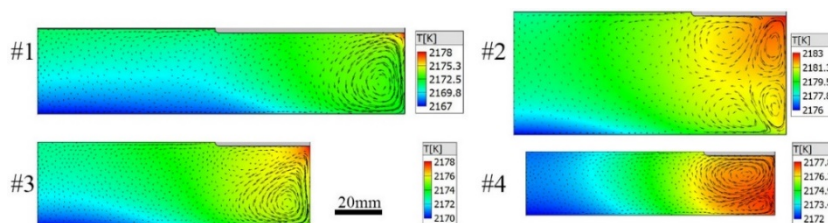

Figure 1 The typical temperature and flow pattern of four conditions given by GA

Figure 2 The photograph of 150 mm TSSG SiC

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