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Study of Nitrogen Concentration in Silicon Carbide

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This work focused on studying the nitrogen concentration (C_N) in SiC. The variations of C_N in the synthesis of SiC powder as well as the transport during SiC crystal growth have been investigated for broad ranges of temperature and Ar pressure. Before SiC crystal growth, SiC powders were synthesized from high-purity silicon and carbon powders. The concentrations of nitrogen, free C, and free Si in the as-prepared powders were all measured. C_N in the SiC source powder decreased with increasing temperature and decreasing Ar pressure, whereas it did not show a remarkable trend with the molar ratio of free Si to free C. SiC crystal was then grown by the physical vapor transport (PVT) technique using the as-prepared powder. The distribution of C_N in the remaining material indirectly indicated the temperature field of crystal growth. In addition, compared with introducing N_2 during SiC crystal growth, doping with nitrogen during synthesis of the SiC source powder might be a better method to control C_N in SiC crystals.

Key words: Nitrogen concentration, silicon carbide, crystal growth, physical vapor transport

INTRODUCTION

As a representative of the third-generation semiconductors, SiC crystal possesses many excellent physical properties, showing promise for applications in high-power, high-frequency, high-temperature electronic and optoelectronic devices.[1] Presently, SiC single crystals are mainly produced by the physical vapor transport (PVT) technique.[2,3] Developments such as increase of wafer diameter up to 6 inches and improvement in crystal quality have paved the way towards greater market penetration of silicon carbide wafers.

Nitrogen (N) is a very common donor impurity, being favorable for low-resistivity SiC crystal but unfavorable for high-purity semi-insulating material. Many researchers have investigated the concentration,[4,5] influential factors,[6–8] and kinetics[9,10] of N-doping, the effect of N-doping on SiC polytypic transformation,[11] and passivation of dangling bonds.[12] These reports mainly focused on SiC wafers, but seldom mention N or its transport process in the SiC source powder during crystal growth, which is very important for understanding how to dope it into or remove it from SiC crystal. Intentional N-doping is often realized by introducing nitrogen gas during the growth process, but it is hard to obtain uniformly N-doped SiC crystal. Unintentional N-doping results partly from insufficient furnace airtightness. Besides, SiC source powder produced by the Acheson method usually contains N concentration (C_N) of approximately 120 ppm. If it is synthesized from silicon and carbon powder, C_N can be adjusted precisely, improving the quality of both low-resistivity and semi-insulating SiC crystal.

In this work, we studied the variation of C_N in the synthesized SiC powders as well as its transport process during SiC crystal growth, aiming at control of C_N in SiC crystal.

EXPERIMENTAL PROCEDURES

SiC powders were synthesized using high-purity silicon (99.999%) and carbon (99.9999%) powder as

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