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Investigations on Polytypic Growth of Silicon Carbide

Jeanette Hvam¹, Terence Warner¹, Per Morgen², Eivind Skou¹ and Thomas Wolff³

¹ Department of Chemical Engineering, Biotechnology and Environmental Technology, University of Southern Denmark, Denmark.

² Department of Physics, Chemistry and Pharmacy, University of Southern Denmark, Denmark.

³ Dinex A/S, DET Germany, Germany

Abstract

For many years SiC has been investigated because many of its properties render it superior to other ceramic materials in many aspects. Silicon carbide is thermally stable at high temperatures, has a high fracture strength and toughness [1-5], is chemically inert and is semiconducting, withstanding high voltage and high frequency, making it ideal for harsh environment applications [2,5,11]. SiC has been produced in more than 250 different polytypes only differing in the stacking sequence, but showing unequal properties [3,4,7,8]. The reason for the polytypic growth and the kinetics behind this has not yet been fully understood and the properties of the different polytypic structures are still being investigated.

SiC exist in the cubic structure, 3C-SiC, also referred to as β -SiC and with hexagonal structure, α -SiC. The β structure has been considered to be the low-temperature polymorph of SiC, but extensive studies over the years have revealed that it is a metastable phase of SiC [3,6,7,8,9]. The α -SiC has been shown to exist in more than 250 different polytypes, though it is mainly produced as the 6H polytype under heat treatment [2,3,10,11]. As an exception, heat treatment of a mixture of Si, C and Al grains under Ar results in the 4H polytype [10, 11]. This ternary system, Al-Si-C, was studied under different circumstances to find an explanation for the polytypic recrystallization of 3C-SiC into the 4H-SiC under these alloying conditions.

We have heated pure silicon, carbon and 5% wt aluminum ~40 micron grains in several steps and characterized the results after each step to determine the kinetics and the role of aluminum on the

production and recrystallization of SiC. The mixture was first pyrolyzed and then heated under vacuum to the temperature where β -SiC is produced at 1450°C in Argon atmosphere. For the conversion from β to α -SiC the temperature is raised to 1950°C for 2h followed by a subsequent cool down, also under Ar. The result is a porous structure of interconnected flake-like hexagonal 4H-SiC crystals and a waste product deposited on the cooler parts of the furnace, as yellow hexagonal flake-like crystals of ternary carbides. *The elemental aluminum plays the role of solvent and diffusion agent under the ceramization process as a quasi-liquid phase and in the conversion process as promoter for the polytypic conversion from 3C-SiC to highly crystalline 4H-SiC by the formation of Al₄SiC₄. The hexagonal SiC structure shows 2D-nucleation growth in the 0001 direction and multiple twinning due to dislocation in the crystal presumably produced by impurities. The 3C polytype was favored when exchanging the atmosphere during conversion with N₂.* The purpose of this work is to clarify the subject of polytypic crystal growth exemplified by the above described conversion and deduced mechanisms.

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