Toyota developed ultrahigh-quality silicon carbide single crystals for next-generation electronic devices

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Mr. Daisuke Nakamura and colleagues in Toyota Central R&D Labs, Inc. developed ultrahigh-quality silicon carbide single crystals which has fewer dislocation density by two to three orders magnitude than the conventional, and published this research in 26 August 2004 issue of the journal Nature.

Silicon carbide (SiC) has a range of useful physical, mechanical and electronic properties that make it a promising material for next-generation electronic devices. Careful consideration of the thermal conditions in which SiC {0001} is grown has resulted in improvements in crystal diameter and quality: the quantity of macroscopic defects such as hollow core dislocations (micropipes), inclusions, small-angle boundaries and long-range lattice warp has been reduced. But some macroscopic defects (about 1-10 cm-2) and a large density of elementary dislocations (10^4 cm^-2), such as edge, basal plane and screw dislocations, remain within the crystal, and have so far prevented the realization of high-efficiency, reliable electronic devices in SiC.

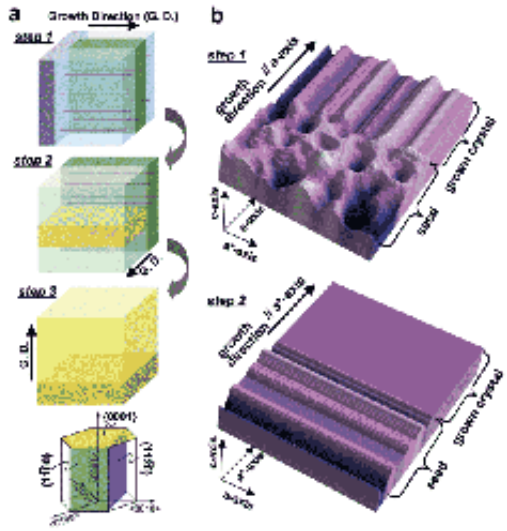

Fig.1. Schematic illustrations of "repeated a-face" growth process

Here the authors report a method, inspired by the dislocation structure of SiC grown perpendicular to the c-axis (a-face growth) (Fig. 1), to reduce the number of dislocations in SiC single crystals by two to three orders of magnitude, rendering them virtually dislocation-free. Actually, The crystal quality of RAF substrates is much better than that of conventional substrates (Fig. 2). The authors consider that it will be possible in the near future to eliminate dislocations perfectly, and to enlarge the diameter to several inches. These substrates will promote the development of high-power SiC devices and reduce energy losses of the resulting electrical systems.

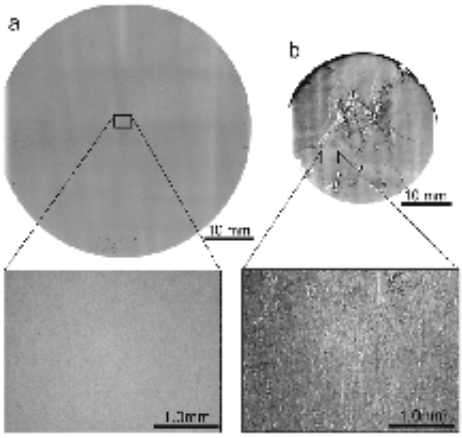

Fig.2. Synchrotron monochromatic beam X-ray topographies

The result will be presented at 5th European Conference on Silicon Carbide and Related Materials (ECSCRM2004), Aug. 31- Sept. 4, Bologna, Italy.

Source: TOYOTA CENTRAL R&D LABS., INC