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Publication date:
2012

Citation (APA):
Kaiser, M., Hupfer, T., Jokubavicus, V., Schimmel, S., Syväjärvi, M., Ou, Y., ... Wellmann, P. (2012). Polycrystalline SiC as source material for the growth of fluorescent SiC layers. Abstract from European Conference on Silicon Carbide and Related Materials (ECSCRM 2012), Saint-Petersburg, Russian Federation.

Polycrystalline SiC as source material for the growth of fluorescent SiC layers

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The emission of donor-acceptor-pair recombination in SiC is well known [1,2]. Especially nitrogen and boron co-doped 6H-SiC layers with B concentrations of more than 10^{18} cm^{-3} show high internal quantum efficiency with the emission peak at about 580nm. The Fast Sublimation Growth Process (FSGP) is a proven technique to produce thick fluorescent SiC (f-SiC) layers of high crystallinity at high growth rates [3] which may be used for the fabrication of a white light emitting diode (LED) structure [4,5] based on a blue InGaN LED grown on the yellow fluorescing SiC substrate. In this work we have investigated the properties of the polycrystalline SiC source materials grown by the PVT method and the impact of the grain properties (grain size, grain polytype and crystallographic grain orientation) on the growth rate during FSGP.

As source material nitrogen and boron co-doped polycrystalline SiC was grown using the PVT technique. Therefore B, in the form of B_4C, was mixed into the SiC powder source with concentrations of 10 ppm, 50 ppm and 100 ppm, respectively. Gaseous nitrogen added to the chamber acted as continuous donor supply. The flux was fixed to 10 sccm resulting in n-type samples for each B concentration run. The growth runs were carried out at temperatures exceeding 2100°C under argon atmosphere at 35 mbar. The supersaturation of the gas species at the top inside a graphite crucible lead to the nucleation of the latter on an isostatically pressed highly purified graphite plate resulting in fine grains of different polytypes (Fig.1 a). During growth successive grain size enlargement can be observed leading to coarse grains in the range of several millimeters after approximately 20 h (Fig.1 b,c). In order to investigate the crystallographic orientation of different grains and their behavior during growth Laue photographs in back reflection geometry were taken from samples cut perpendicular to the z-axis. It was found that the <0001> directions of the investigated grains inclines angles (off-axis angles, tilting) as low as 4° up to 30° in respect to the z-axis of the crucible, e.g. the symmetry axis of the setup. Their projections on the x-y-plane show, that they incline various angles in respect to the x-axis (Fig.2 a). Moreover it has to be stated that the grains do not grow textured and tilting does not appear towards the same crystallographic direction. Polytype identification was done using

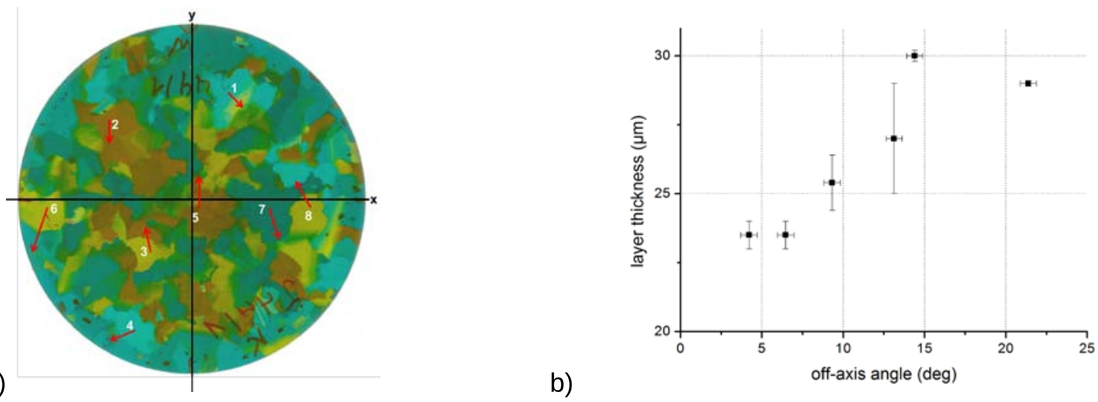
Raman spectroscopy in back scattering geometry. It pointed out that mainly the 15R modification forms under high tilt angles, e.g. more than 15°. Furthermore polytype switches appear within one grain.
As the polycrystalline source material consists of various polytypes and areas of different crystallographic orientation, we have investigated their influence on the sublimation epitaxy in terms of growth rate as well as the incorporation of dopants. By using a graphite mask between the polycrystalline source and the substrate only specific grains were allowed to sublime and therefore the influence of the tilt angle on the growth rate in the FSGP could be studied leading to different layer thicknesses for a fixed growth time (Fig.2 b). It is shown that the growth rate increases with increasing off-axis angle emerging a maximum at approximately 15° followed by a decrease of less intense compared to the increase.

Acknowledgment

This work was supported by Bundesministerium für Bildung und Forschung (BMBF, contract 03SF0393), Ångpanneföreningen Research Foundation Swedish Energy Agency, Nordic Energy Research, Swedish Research Council (No. 2009-5307).

a) b) c)

Fig. 1 a) Polycrystalline wafer after nucleation, b) after approximately 10h and c) approximately 20h of growth showing continuous grain size enlargement. The diameter of the wafers is 50mm.



a) b)

Fig. 2 a) Projection of the <0001> directions (red arrows) on the x-y-plane, b) layer thickness vs. off-angle for isolated grains used as source in the FSGP.

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