Electrical and Optical Characterization of p-Type Boron Doped 6H-SiC Bulk Crystals

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Boron/Vanadium co-doping has recently attracted interest in SiC bulk crystal growth [1]. Controlled p-type co-doping is required to activate the almost mid-gap V donor level exhibiting superior semi-insulating properties. To get information about the boron incorporation the electrical and optical properties of SiC doped with boron during PVT bulk growth have been studied.

We have performed temperature-dependent Hall effect measurements in the range of 50 K up to 750 K to determine the charge carrier concentration. From these data the concentration of boron as well as that of compensating impurities can be calculated via the charge carrier neutrality equation. We will show that while the incorporation of boron during growth time is nearly constant (its value depends only on boron content in the source material [2] and growth temperature), compensation by nitrogen has a decisive influence on the electrical properties (see fig. 1).

Measurements of the optical absorption coefficient α at room temperature were used to correlate the optically detected band-gap shrinkage (BGS) and the boron related below band-gap absorption (BBGA) [3,4] to the electrical measurements. As shown in fig. 2, in B doped 6H-SiC the BGS determined by an $\alpha^{1/2}$ / E plot is linearly correlated with the BBGA absorption at 730 nm. Though the origin of this BBGA peak is yet unclear, it is shown to be related to the boron content in the crystal.

The absorption data are compared to the Hall effect measurements taking into account the concentration of boron and compensating impurities in the crystals. For SiC wafers with a boron content less than 2×10^{19} cm^{-3}, charge carrier concentration can be determined by absorption data using a calibration curve, whereas for higher boron concentrations deviations occur which will be addressed in details in our presentation.

[1] M.Bickermann, D.Hofmann, T.L.Straubinger, R.Weingärtner, A.Winnacker, ICSCRM 01 preprint, to be published in Mater. Sci. Forum (2002)

[2] M.Bickermann, B.M. Epelbaum, D.Hofmann, T.L.Straubinger, R.Weingärtner, A.Winnacker, J. Cryst. Growth 233 (2001) 211

[3] R.Weingärtner, P.J.Wellmann, M.Bickermann, D.Hofmann, T.L.Straubinger, A.Winnacker, Appl. Phys. Lett. 80 (2001) 70

[4] P.J.Wellmann, S.Bushevoy, R.Weingärtner, Mater. Sci. Eng. B 80 (2001) 352

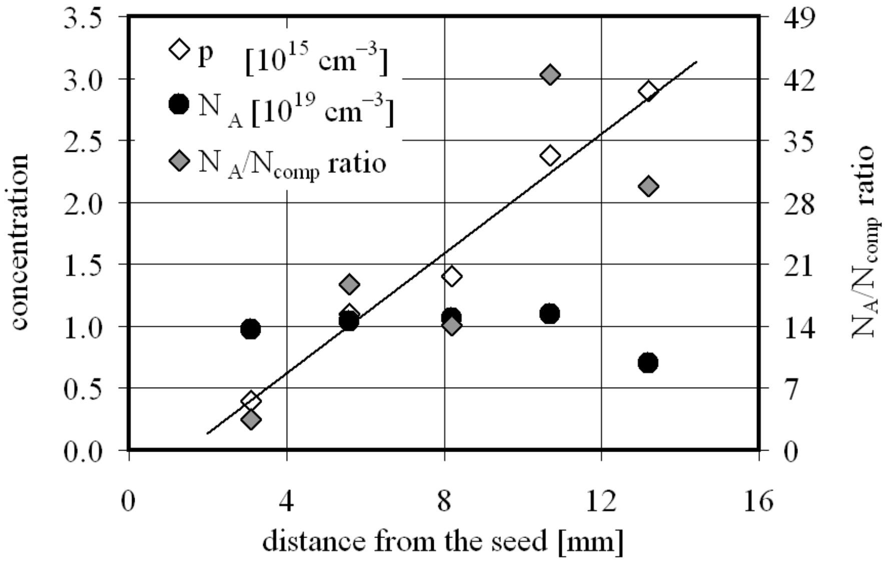

Fig. 1: Axial evolution of the charge carrier concentration p and the boron concentration N_A calculated from temperature-dependent Hall effect measurements in a boron doped 6H-SiC crystal. The charge carrier concentration in boron doped SiC samples is linearly correlated to the N_A/N_{comp} ratio while the boron incorporation stays virtually constant with growth time.

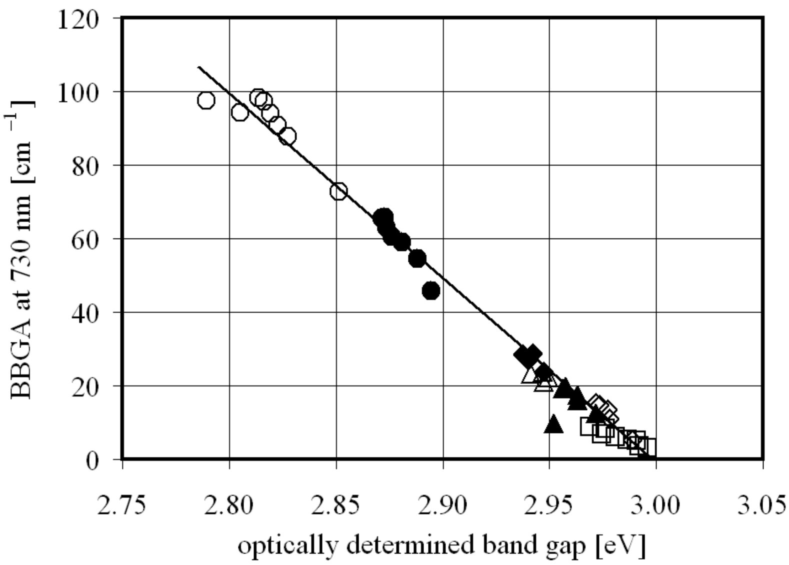

Fig. 2: Dependence of the boron-related below band-gap absorption (BBGA) peak at 730 nm on the optically determined band gap E determined by an $\alpha^{1/2}$ / E plot according to [4]. The different symbols denote different B doped 6H-SiC crystals.