ESR and photoconductivity studies of n- and p-type polycrystalline 3C SiC

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The bulk pc-SiC samples of 3C polytype were obtained by thermal decomposition of CH_3SiCl_3 vapor in a hydrogen atmosphere. Two series of the 3C pc-SiC samples were studied. The first set of the samples was initial n-type 3C pc-SiC with $(N_D - N_A) \approx 5 \cdot 10^{16}$-$2\ 10^{18}$ cm^{-3} with specific resistance 10^{-1}-10^{1} Ω·cm. The second set of the samples was p-type pc-3C SiC doped with boron during the growth process with specific resistance 10^{2}-10^{4} Ω·cm. The structural analysis has shown that the obtained samples are single phase stoichiometric SiC. The temperature dependence of photocurrent was measured at T = 80-600 K, while the time-resolved photoresponse decay was recorded after an excitation by square pulse at 77 K. The ESR measurements were performed on X-band (9.4 GHz) Bruker ELEXYS E580 spectrometer at T = 6-297 K.

It was found that in the n-type 3C pc-SiC samples the intensity ratio between impurity and intrinsic photoconductivity (PC) signals is higher than those observed in n-type 3C SiC monocrystals. The relaxation processes in n-type pc-3C SiC turned out to be more inertial than those observed in n-type 3C SiC monocrystals and the value of the residual PC was found to be higher in the pc 3C SiC. After the boron doping the properties of 3C pc-SiC were changed significantly. In p-type 3C pc-SiC the intensity of impurity PC signal increases in comparison to those measured in n-type 3C pc-SiC. At the same time the impurity PC in p-type p3C pc-SiC is higher than the intrinsic one. The photocurrent decay curves in p-type 3C pc-SiC turned out to be shorter than those in n-type 3C pc-SiC. The observed differences in the behavior of the PC in n-type 3C pc-SiC pc and SiC monocrystals as well as the distinction in the photocurrent decay for n- and p-type 3C pc-SiC can be explained by the presence of the intrinsic defects and different degree of their compensation in n- and p-type 3C pc-SiC.

The ESR spectra measured in 3C pc-SiC of n- and p- type at T = 297 K consist of three overlapping signals with isotropic g-factors (g_{iso}) and different linewidth (H_{pp}). These signals are typically observed in 3C epitaxial layers and films. As a result, we may attribute the first signal with g_{iso} = 2.0029(3), H_{pp} = 0.2 mT to the carbon dangling bonds (CDB). The second signal with g_{iso} = 2.0042(3), H_{pp} = 0.22 mT was assigned to silicon dangling bonds (SiDB). And the third signal with g_{iso} = 2.0040(3), H_{pp}=0.5-0.6 mT can be attributed to the D-center (a Si excess defect, (·Si≡Si_3)). With the temperature decrease the intensity of SiDB ESR line in n-type 3C pc-SiC dramatically increase exhibiting the typical behavior for this type of the paramagnetic center. The absence of the nitrogen ESR spectrum in n-type 3C pc-SiC (in contrast to the n-type 6H SiC micropowders) can be explained by the compensation of nitrogen donors by deep level defects. At T < 100 K the quartet hyperfine lines were observed in p-type 3C pc-SiC due to the boron acceptor substituting cubic site (B_k) in 3C SiC. The spin concentration of the CDB, SiDB and D-center was significantly lower in p-type 3C pc-SiC than that in n-type samples that can be explained by their compensation by boron acceptors.

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