Donor Densities and Donor Levels in 3C-SiC Determined by a New Method Based on Hall-Effect Measurements

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Silicon carbide (SiC) has been regarded as a promising semiconductor for power electronic applications owing its excellent physical properties. In order to use SiC wafers or epilayers for electronic devices, an accurate evaluation of densities and energy levels of dopants in SiC is essential. One of the authors has proposed and experimentally tested a graphical method for determining those of several dopants using the temperature dependence $n(T)$ of the majority-carrier concentration obtained by Hall-effect measurements.[1-4)] We apply this method to determine donor densities (N_D) and donor levels (ΔE_D) in undoped 3C-SiC grown on silicon by chemical vapor deposition using $Si_2(CH_3)_6$ that is called HMDS.

In the proposed method, the function $H(T, E_{ref})$ to be evaluated is defined by

$$H(T, E_{ref}) \equiv \frac{n(T)^2}{(kT)^{2.5}} \exp\left(\frac{E_{ref}}{kT}\right)$$

where k is the Boltzmann constant, T is the absolute temperature and E_{ref} is a parameter that can shift the peak temperature (T_{peak}) of $H(T, E_{ref})$ within the measurement temperature range. Since T_{peak} corresponds to one ΔE_D, from each peak temperature and peak value, ΔE_D and N_D of the corresponding dopant can be accurately determined.

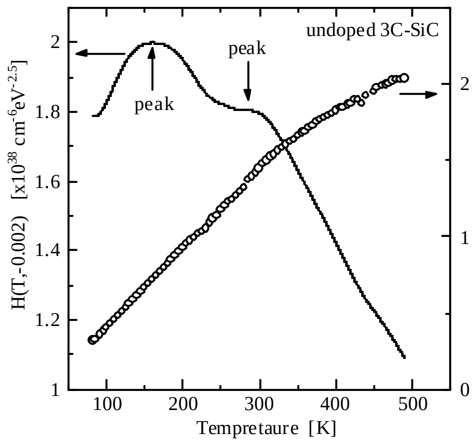

Fig.1 n(T) and H(T,-0.002)

Figure 1 shows $n(T)$ denoted by open circles and $H(T,-0.002)$ denoted by the solid line in 32 μm thick 3C-SiC. Since two peaks appeared in the figure, at least two types of donors existed in the 3C-SiC. From the detailed analysis, three types of donors were found to exist. Their ΔE_D and N_D were determined to be 14 meV and 4.7x10^{16} cm^{-3}, 54 meV and 8.1x10^{16} cm^{-3}, and 120 meV and 1.0x10^{17} cm^{-3}, respectively. The acceptor density (N_A) was determined to be 5.7x10^{15} cm^{-3}. Figure 2 shows the experimental $n(T)$ and the $n(T)$ simulated with the obtained values. Since the simulated $n(T)$ is quantitatively in agreement with the experimental $n(T)$, the obtained values are considered to be reliable.

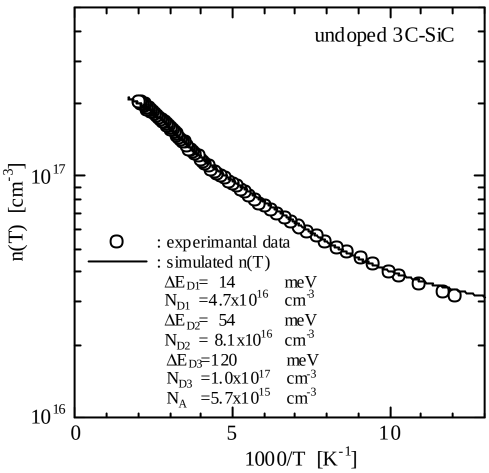

Fig. 2 Experiemtal and simulated n(T)

We investigated three kinds of 3C-SiC thicknesses (8 μm, 16 μm and 32 μm). The values of N_D for 14 meV and 54 meV donors decreased with an increase in 3C-SiC thickness, while N_D for 120 meV was independent of its thickness.

References 1) H. Matsuura: Jpn. J. Appl. Phys. 36(1997)3541. 2) H. Matsuura et al.: Jpn. J. Appl. Phys. 37(1998)6034. 3) H. Matsuura et al.: Jpn. J. Appl. Phys. 38(1999)4013. 4) H. Matsuura et al.: Appl. Phys. Lett. 76(2000) 2092.