Reduction in Al Acceptor Density by Electron Irradiation in Al -Doped 4H-SiC

Hideharu Matsuura, Koichi Aso, So Kagamihara, Hirofumi Iwata, Takuya Ishida, and Kazuhiro Nishikawa[1]
Osaka Electro-Communication University, 18-8 Hatsu-cho, Neyagawa, Osaka 572-8530, Japan
[1] Sansha Electric Mfg. Co. Ltd., 3-1-56 Nishi-Awaji, Higashi-Yodogawa, Osaka 533-0031, Japan
TEL/FAX: +81-72-820-9031, E-mail: matsuura@isc.osakac.ac.jp

The influence of electron irradiation on the hole concentration in Al-doped 4H-SiC is investigated from Hall-effect measurements. A 10 μm-thick Al-doped 4H-SiC epilayer (Al-doping density: $\sim 5\times10^{15}$ cm^{-3}) on n-type 4H-SiC was cut into a 1×1 cm^2 in size. After the temperature dependence of the hole concentration p(T) was measured by the van der Pauw method in a magnetic field of 1.4 T, the sample was irradiated by 4.6 MeV electrons with 2.6×10^{14} cm^{-2} fluence. Then, the p(T) in the irradiated sample was measured.

The p(T) was reduced by the electron irradiation in the whole temperature range. From the Hall-effect analysis, the densities and energy levels of acceptors or hole traps are determined. In both the samples, ~200 meV and ~370 meV acceptor levels or hole-trap levels are detected. According to literature, the ~200 meV energy level corresponds to the Al acceptor level in 4H-SiC, while the origin of the other energy level is unknown. By irradiation, the Al acceptor density is only reduced from $6.2x10^{15}$ cm^{-3} to $8.2x10^{14}$ cm^{-3}. Therefore, it is found that the reduction in p(T) by the electron irradiation resulted from the decrease of the Al acceptor density.

Reduction in Al Acceptor Density by Electron Irradiation in Al -Doped 4H-SiC

Hideharu Matsuura, Koichi Aso, So Kagamihara, Hirofumi Iwata, Takuya Ishida, and Kazuhiro Nishikawa[1]
Osaka Electro-Communication University, 18-8 Hatsu-cho, Neyagawa, Osaka 572-8530, Japan
[1] Sansha Electric Mfg. Co. Ltd., 3-1-56 Nishi-Awaji, Higashi-Yodogawa, Osaka 533-0031, Japan
TEL/FAX: +81-72-820-9031, E-mail: matsuura@isc.osakac.ac.jp

The influence of electron irradiation on the hole concentration in Al-doped 4H-SiC is investigated from Hall-effect measurements. A 10 μm-thick Al-doped 4H-SiC epilayer (Al-doping density: ~5×10^{15} cm^{-3}) on n-type 4H-SiC was cut into a 1×1 cm^2 in size. From secondary ion mass spectroscopy, the concentration of B in this epilayer was estimated to be < $4x10^{14}$ cm^{-3}. Ohmic metal (Al/Ti) was deposited on four corners, and then the sample was annealed at 900 °C in an Ar atmosphere for 1 min. The temperature dependence of the hole concentration p(T) was measured by the van der Pauw method in the temperature range of 135 K and 580 K and in a magnetic field of 1.4 T. After the measurement, the sample was irradiated by 4.6 MeV electrons with 2.6×10^{14} cm^{-2} fluence. Then, the p(T) in the irradiated sample was measured.

Although the radiation damages have been mainly studied from electron paramagnetic resonance spectroscopy and deep level transient spectroscopy, the densities and energy levels of hole traps created by irradiation can also be accurately determined using p(T) from free carrier concentration spectroscopy (FCCS) [1], which is a graphical peak analysis method for determining these values without any assumption regarding acceptor species and hole traps.

Figure 1 shows two p(T) in the unirradiated and irradiated samples, which are denoted by circles and diamonds, respectively. The p(T) was reduced by the electron irradiation in the whole temperature range. From the FCCS analyses [1,2,3], the densities and energy levels of acceptors or hole traps are determined, which are listed in Table 1. In both the samples, ~200 meV and ~370 meV acceptor levels or hole-trap levels are detected. According to literature [4,5], the ~200 meV energy level corresponds to the Al acceptor level in 4H-SiC, while the origin of the other energy level is unknown. As is clear from the table, only the Al acceptor density is reduced by the electron irradiation. Therefore, it is found that the reduction in p(T) by the electron irradiation resulted from the decrease of the Al acceptor density.

References

[1] H. Matsuura, Y. Uchida, T. Hisamatsu, and S. Matsuda: Jpn. J. Appl. Phys. Vol. 37(1998), p. 6034.
[2] H. Matsuura, Y. Masuda, Y. Chen and S. Nishino: Jpn. J. Appl. Phys. Vol. 39 (2000), p. 5069.
[3] H. Matsuura, K. Morita, K. Nishikawa, T. Mizukoshi, M. Segawa and W. Susaki: Jpn. J. Appl. Phys. Vol. 41 (2002), p. 496.
[4] M. Ikeda, H. Matsunami and T. Tanaka: Phys. Rev. Vol. B22 (1980), p. 2842.
[5] T. Troffer, M. Schadt, T. Frank, H. Itoh, G. Pensl, J. Heindl, H. P. Strunk and M. Marier: Phys. Stat. Sol. (a) Vol. 162 (1997), p. 277.

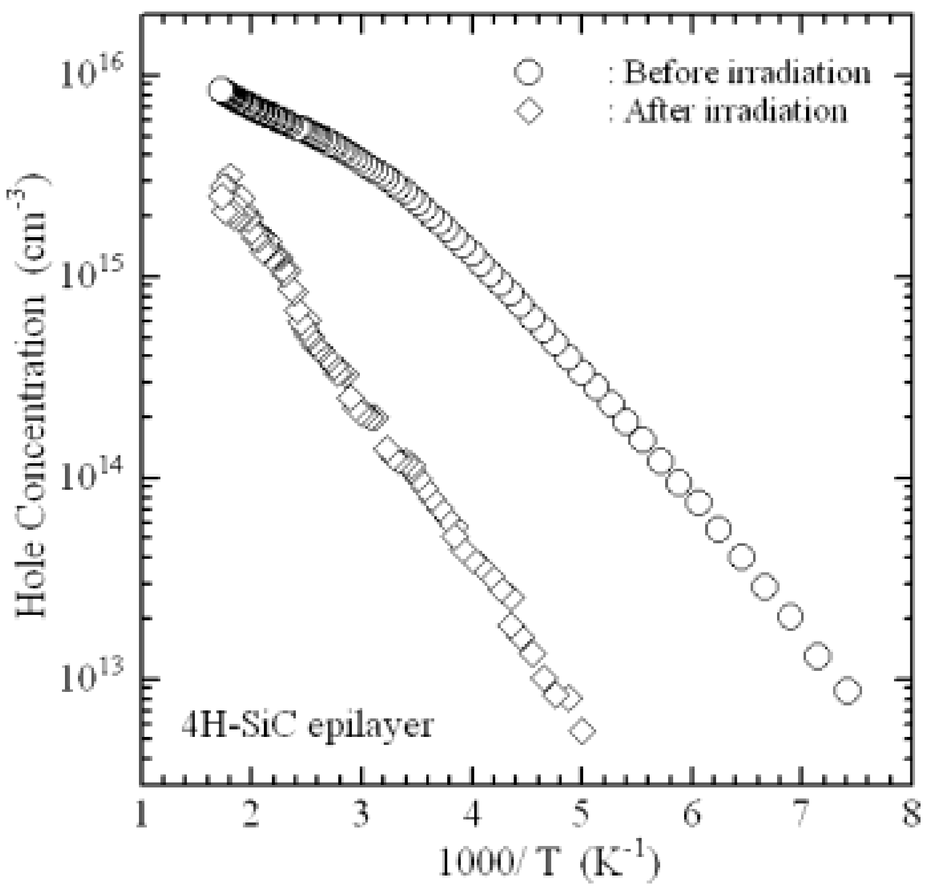

Fig. 1. Temperature dependences of hole concentration in Al-doped 4H-SiC before and after electron irradiation.

Table 1 Results obtained from Hall-effect analysis.

	Before irradiation	After irradiation
ΔE_{A1} [meV]	203	206
N_{A1} [cm^{-3}]	6.2×10^{15}	8.2×10^{14}
ΔE_{A2} [meV]	365	383
N_{A2} [cm^{-3}]	4.2×10^{15}	3.4×10^{15}
N_{comp} [cm^{-3}]	3.4×10^{13}	7.4×10^{14}