Relationship between defects induced by irradiation and reduction of hole concentration in Al-doped 4H-SiC

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Keywords: radiation damage, defect, hole concentration, Al-doped 4H-SiC

From the temperature dependence of the hole concentration p(T) in Al-doped 4H-SiC epilayers irradiated with 4.6 MeV electrons with 2.6×10^{14} e/cm^2, we reported that the density of one acceptor species with 200 meV was significantly reduced while the density of the other acceptor with 350 meV was slightly decreased [1]. From photoluminescence studies, the shallow acceptor was ascribed to an Al atom at a Si site (Al_{Si}). On the other hand, the origin of the deep acceptor was not assigned.

The possible main mechanism of the reduction in the p(T) by the irradiation is (1) a decrease in the Al acceptor density because the Al_{Si} is moved into the interstitial site or because the bond between the Al_{Si} and the nearest neighbour C atom is broken, or (2) the creation of deep hole traps or donor-like defects.

10 um-thick Al-doped 4H-SiC epilayers were used. The p(T) was obtained by Hall-effect measurements, shown in Fig.1.

One electron with 200 keV can displace only the C atom, whereas one electron with >500 keV is sufficient to displace the Al or Si atom. By irradiation with 200 keV electrons with 1×10^{16} cm^{-2}, the decrement of the Al acceptor density is close to the increment of the unknown deep acceptor density, shown in Table 1. This suggests that the bond between the Al_{Si} and the nearest neighbour C atom is broken by the displacement of the C atoms, which results in a decrease in the Al acceptor density and an increase in the density of an Al_{Si}-V_C complex of the Al_{Si} and the nearest neighbour C vacancy. Therefore, the origin of the deep acceptor is considered to be Al_{Si}-V_C.

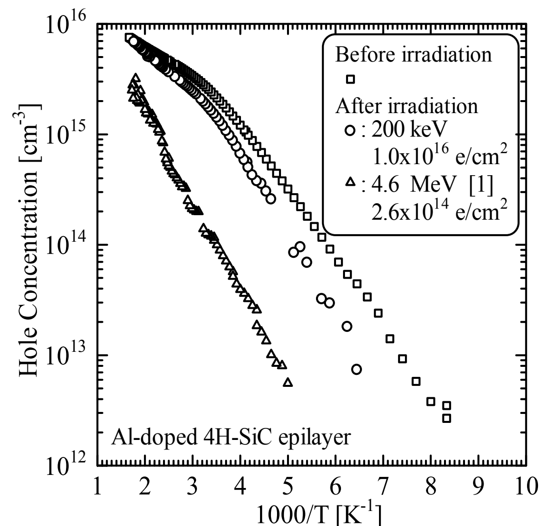

Fig. 1 Hole concentrations.

Table 1 Results from the p(T).

	unirradiated	200 keV	4.6 MeV [1]
ΔE_{A1} [meV]	203	217	206
N_{A1} [$\times 10^{15}$ cm^{-3}]	5.2	4.3	0.82
ΔE_{A2} [meV]	357	363	383
N_{A2} [$\times 10^{15}$ cm^{-3}]	3.5	5.2	3.5
N_{comp} [$\times 10^{15}$ cm^{-3}]	0.047	0.21	0.74

1. H. Matsuura et al., Appl. Phys. Lett. **83**, 4981 (2003).

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