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Mechanisms of reduction in hole concentration in Al-doped 4H-SiC by electron irradiation

From the temperature dependence of the hole concentration p(T) in Al-doped 4H-SiC irradiated with 4.6 MeV electrons with 2.6×10^{14} cm^{-2}, we reported that the density of one acceptor species with E_V+200 meV was significantly reduced while the density of the other acceptor with E_V+350 meV was slightly decreased, where E_V is the valence band top. From photoluminescence and Hall-effect measurements, 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 is not assigned.

The possible mechanisms of the reduction in the p(T) by the irradiation are as follows; (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 neighbor C atom is broken, or (2) the creation of deep hole traps or donor-like defects.

A 10 um-thick Al-doped 4H-SiC epilayer (doping density: 5×10^{15} cm^{-3}) was used. The p(T) was obtained by Hall-effect measurements.

One electron with <250 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. This suggests that the bond between the Al_{Si} and the nearest neighbor 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 a complex (Al_{Si}-V_C) of the Al_{Si} and the nearest neighbor C vacancy. Therefore, the origin of the deep acceptor is considered to be Al_{Si}-V_C.

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