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# Reduction in Majority-Carrier Concentration in Lightly-Doped 4H-SiC Epilayers by Electron Irradiation

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By comparing electron-radiation damage in p-type 4H-SiC with that in p-type Si [1,2], it was found that the reduction in the temperature-dependent hole concentration, p(T), in Al-doped p-type 4H-SiC by electron irradiation was much larger than in Al-doped p-type Si. In Al-doped 4H-SiC, the density of Al acceptors with energy level $E_V$+0.22 eV ($N_{Al}$) decreased significantly with increasing total fluence (Φ) of 200 keV electrons, whereas the density of deep acceptors with energy level $E_V$+0.38 eV ($N_{DA}$) initially increased with Φ and then decreased [2]. In unirradiated Al-doped 4H-SiC epilayers, on the other hand, the relationship of $N_{DA} = 0.6N_{Al}$ was obtained for $8x10^{14} < N_{Al} < 5x10^{16}$ $cm^{-3}$ [3], suggesting that the deep acceptors may be related to Al. Furthermore, we investigated the mechanisms of changes of p(T) in Al-doped 6H-SiC by electron irradiation and annealing [4].

In this study, we have investigated the change of p(T) in lightly Al-doped 4H-SiC epilayers by 100 or 150 keV electron irradiation. Moreover, the decrease in the electron concentration, n(T), in lightly N-doped n-type 4H-SiC epilayers by 200 keV electron irradiation has been investigated.

In the lightly Al-doped 4H-SiC, p(T) was unchanged by 100 keV electron irradiation at fluences less than $7x10^{16}$ $cm^{-2}$. From the analyses of experimental p(T), it was found that both of $N_{Al}$ and $N_{DA}$ were unchanged by the irradiation, and that the density of deep levels created by the irradiation was much less than the acceptor density.

150 keV electron irradiation, on the other hand, reduced p(T), as shown in Fig. 1. This suggests that the 150 keV electron irradiation can displace substitutional C atoms. From the analyses of experimental p(T), at fluences less than $5x10^{16}$ $cm^{-2}$, $N_{Al}$ was decreased with increasing Φ, while $N_{DA}$ was increased with Φ. By the irradiation, moreover, the increment of $N_{DA}$ was nearly equal to the decrement of $N_{Al}$, suggesting that the irradiation might convert the Al acceptors into the deep acceptors.

In the lightly N-doped 4H-SiC, n(T) over the temperature range of the measurement was reduced by 200 keV electrons, as shown in Fig. 2. This result is quite different from that in the lightly Al-doped 4H-SiC, because p(T) in Al-doped 4H-SiC was reduced only at low temperatures by 200 keV electrons [2].

We will discuss the electron-energy dependence of the reduction in p(T), and the mechanisms of reduction in p(T). Furthermore, we will investigate the fluence dependence of the density of N donors located at hexagonal or cubic C-sublattice sites.

**References**
[1] H. Matsuura, et al., Jpn. J. Appl. Phys. **45**, 2648 (2006).
[2] H. Matsuura, et al., J. Appl. Phys. **104**, 043702 (2008).
[3] H. Matsuura, et al., J. Appl. Phys. **96**, 2708 (2004).
[4] H. Matsuura, et al., Physica B **404**, 4755 (2009).

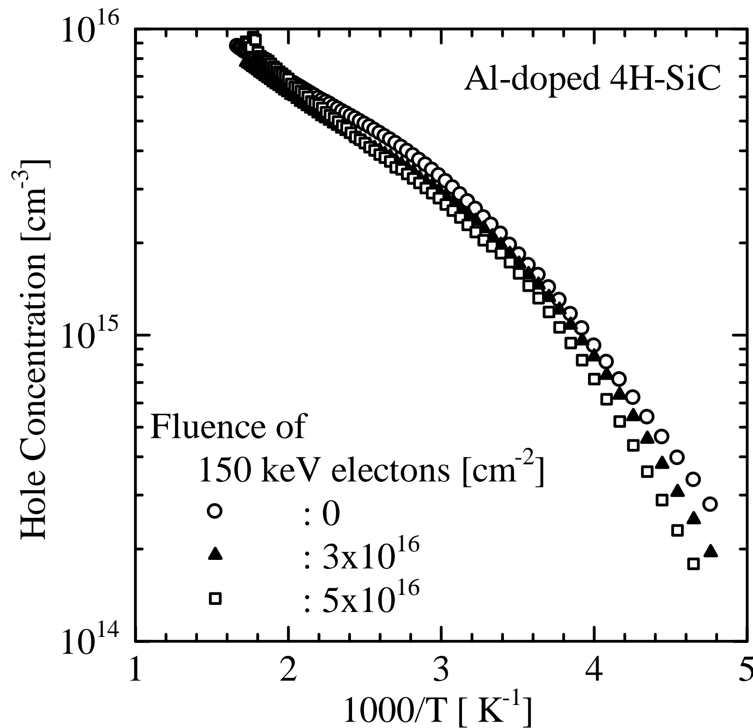


Fig. 1. Temperature dependence of hole concentration for lightly Al-doped 4H-SiC epilayer before and after irradiation with 150 keV electrons.

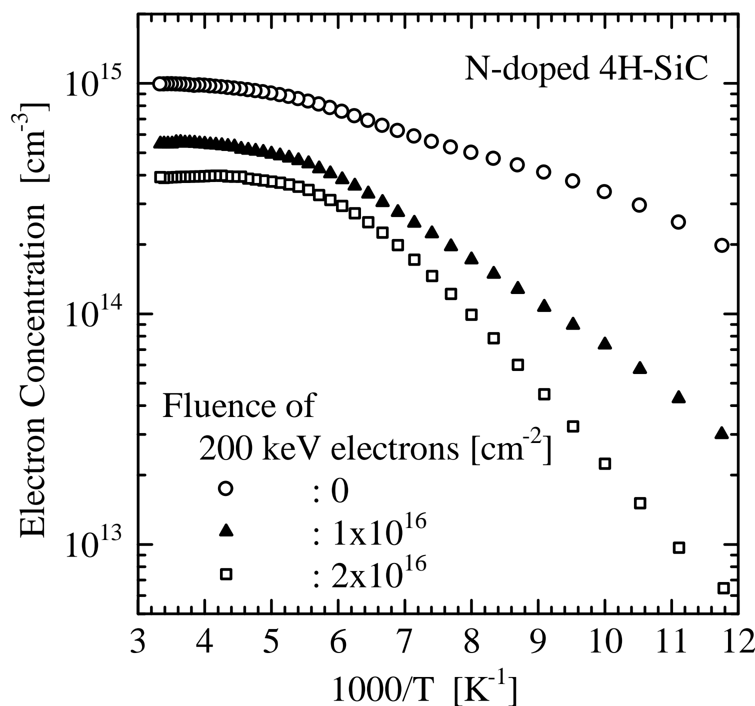


Fig. 2. Temperature dependence of electron concentration for lightly N-doped 4H-SiC epilayer before and after irradiation with 200 keV electrons.