Annealing Study of Defects in Epitaxial SiC Layers Induced by He and Electron Irradiation

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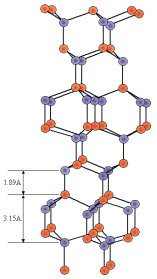
Motivation

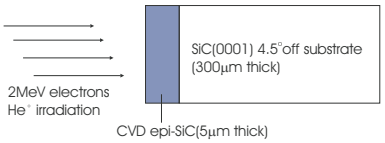
SiC is a wide band-gap semiconductor. Epitaxial SiC is expected as high power device material. Lattice defects are introduced during processes, e.g., ion implantation and heat treatment. Some defects are useful to control minority carrier lifetime. It is necessary to know the origins of electrical active centers in SiC generated by ion and electron irradiation.

The aim of this work to identify vacancy-type defects in epitaxial SiC introduced by He and electron irradiation by positron annihilation and reveal the correlation between positron annihilation centers and electronic levels.

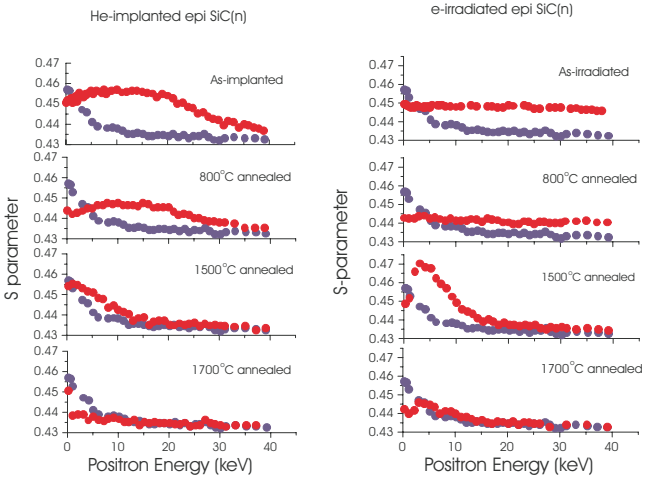


Experimental

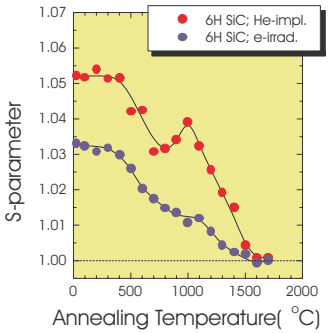
Sample	High-quality 6H SiC epitaxial layer (5μm thick) n-type and p-type (carrier density= 5×10^{15} cm^{-3})
Irradiation	2 MeV electrons with 3×10^{17} e/cm^2 at RT He implantation (30-950keV) at RT
Annealing	Vacuum or Ar ambient ,100-1700°C, 30min
Measurement	Slow positron beam based Doppler broadening (Halle), lifetime (München) measurements and Deep Level Transient Spectroscopy (Erlangen)

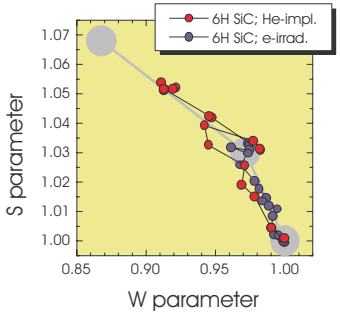


Annealing behavior

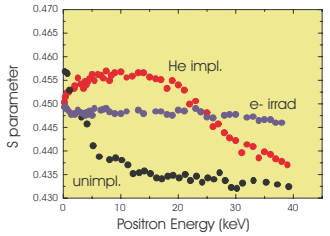


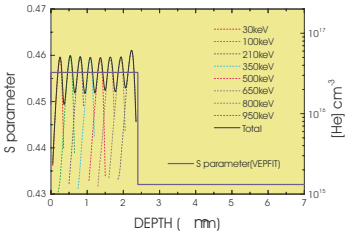
Defects	S	W	REF.
V_{Si}	1.031	0.9718	1,2
$V_{Si}V_C$	1.068	0.8668	2

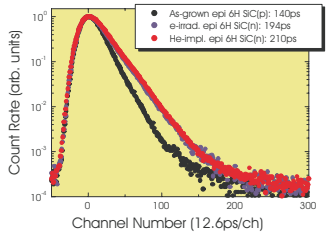




Open-volume defects and Deep levels by He and electron irradiation







Theoretical lifetime REF.3

State	e' lifetime
Bulk	141 ps
V_C	153 ps
V_{Si}	194 ps
$V_{Si}V_C$	214 ps

Discussion

Implantation profile of He by TRIM simulation and damage profile by positron annihilation agree to each other.

Open-volume defects are introduced by both He and electron irradiation.

Defects disappear in two stages at 600 - 700°C and 1000 - 1500°C. In electron-irradiated 6H SiC, both stages are probably due to Si vacancies (V_{Si}). The first stage may be responsible for pure V_{Si} and the second stage V_{Si} + impurity. In He-implanted 6H SiC, vacancies larger than V_{Si}, e.g., $V_{Si}V_C$, are also generated.

References

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2. A. Kawasuso, private communication
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