Effect of illumination on positron lifetime of electron irradiated n-type 6H SiC

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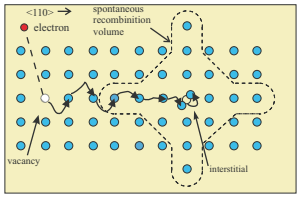
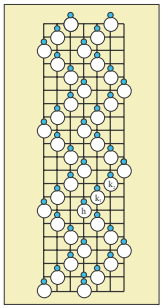
Motivation

- SiC - Key material for high power and high frequency electronic devices
- Ion implantation - standard procedure for selective doping of SiC
- Electron irradiation - controling of minority carrier lifetime
- Identification of vacancy-type defects induced by electron irradiation
- E1/E2 level (negative-U behavior DLTS [Hem99]) - related to vacancy-type defects?
- Observation of metastable defect [Hem99a] through optical illumination with white light and monochromatic light

Structure, Irradiation

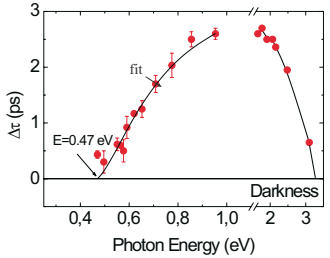


- Frenkel defects introduced after high-energy electron (2MeV) irradiation [Ber92]



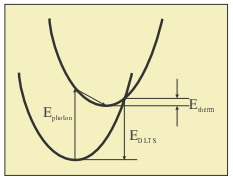
6H SiC structure
carbon sites
silicon sites

Monochromatic Illumination

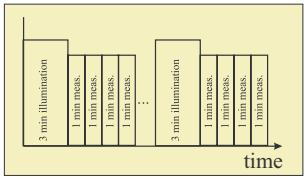


- The data were fitted to the Lucowsky model [Luc65] which gives the cross section for electron transition from a localized state to a parabolic and isotropic band. The threshold energy is determined to be E=0.47eV.
- Illumination effect disappears above 3eV due to indirect transition of electrons from the valence band to the conduction band.
- Above 0.4 eV electrons are probably excited from localized levels to the conduction band. Thus, the charge state will change from negativ to neutral.

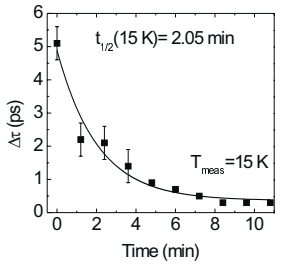
Persistency



simplified configuration coordinate diagramm

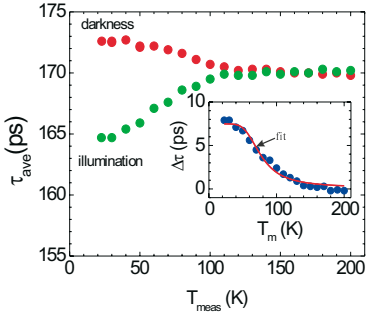


schematic measurement procedure



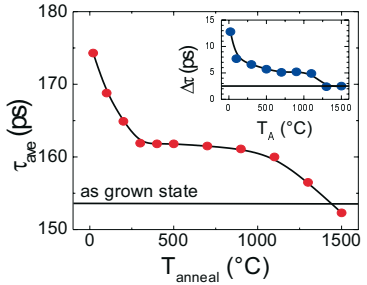
- Illumination effect disappears after 10 min
- Small energy barrier between the excited state and the ground state

Illumination



- After illumination with white light a decrease of the average positron lifetime appears below 110 K
- The spectra decomposition shows a defect-related lifetime of 185 ps (V_{Si}) [Bra96] either in darkness or under illumination. The intensity decreases from 45% to 17% under illumination.
- The illumination effect appears also in as-grown material. The irradiation with 2 MeV was done to introduce additional Frenkel pairs.
- In the inset the difference of positron lifetime under illumination and darkness is presented. (the fitted Energy barrier: 32 meV)
- $\Delta\tau = \tau_{dark} - \tau_{illum}$

Annealing



- Two annealing steps appear.
- The illumination effect and the vacancies disappear approximately at the same temperature.
- The E_1/E_2 defect also disappears at that temperature region [Zha89]

Summary

- after irradiation with 2 MeV electrons, the illumination effect (difference of the average positron lifetime under illumination and in darkness in the as grown state was $\Delta\tau$=2.5ps) in n-type 6H SiC increases
- most of induced defects annealed out at a temperature of 1400°C
- the decomposition of the lifetime spectra shows a defect-related positron lifetime similar to the silicon vacancies
- the observed treshold energy for the illumination effect (0.47eV) is higher than the measured energy level (DLTS:0.3eV/0,4eV) for the E_1/E_2 defect

References

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