Determination of Intrinsic Defects in High-Purity Semi-Insulating 4H-SiC by Discharge Current Transient Spectroscopy

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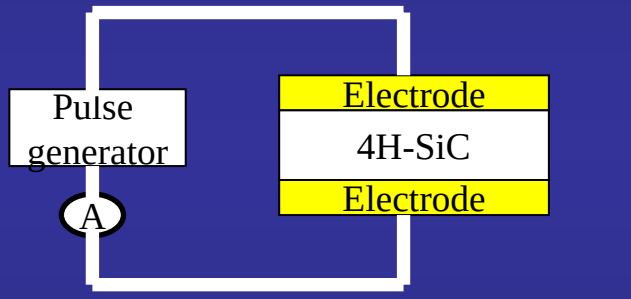
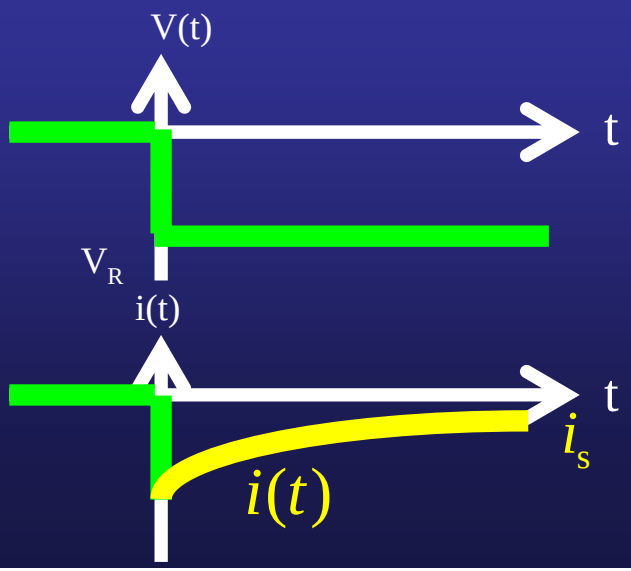
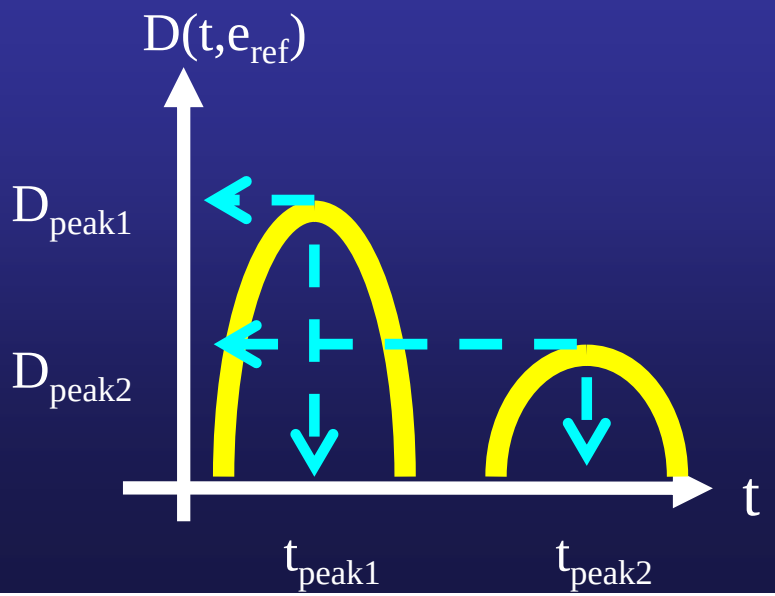
Abstract. To determine the energy levels of intrinsic defects in high-purity semi-insulating 4H-SiC, we apply discharge current transient spectroscopy (DCTS) that is a graphical peak analysis method based on the transient reverse current of a Schottky barrier diode, because transient capacitance methods such as deep level transient spectroscopy and isothermal capacitance transient spectroscopy are feasible only in low-resistivity semiconductors. Seven intrinsic defects are detected in the high-purity semi-insulating 4H-SiC. From the temperature dependence of the emission rate of each intrinsic defect, its activation energy can be determined.



Definition of DCTS [1)]

$$D(t, e_{\mathrm{ref}}) \equiv t\left[i(t) - i_{\mathrm{s}}\right]\frac{\exp\left(-e_{\mathrm{ref}}\, t + 1\right)}{qS}$$





From the peak time and value

i-th trap

Emission rate

$$e_{ti} = \frac{1}{t_{\mathrm{peak}i}} - e_{\mathrm{ref}}$$

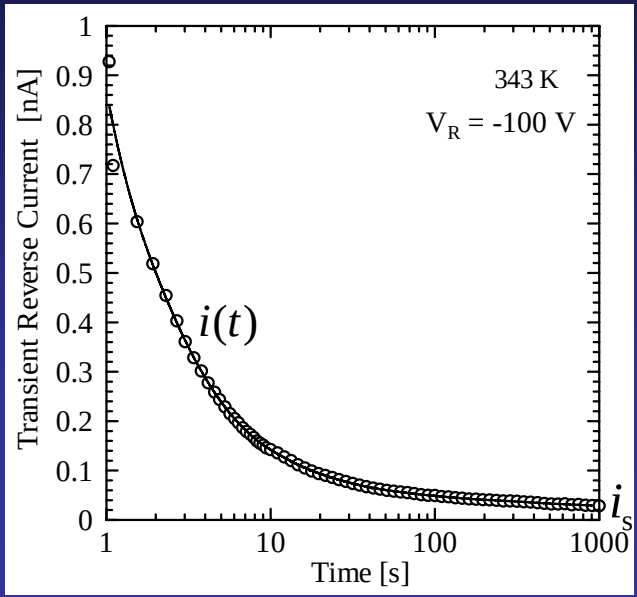
Density

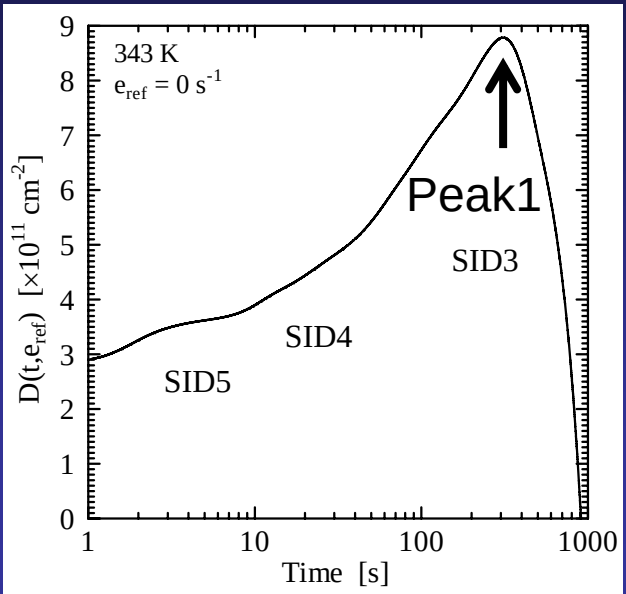
$$N_{ti} = \frac{D_{\mathrm{peak}i}}{1 - e_{\mathrm{ref}}\, t_{\mathrm{peak}i}}$$

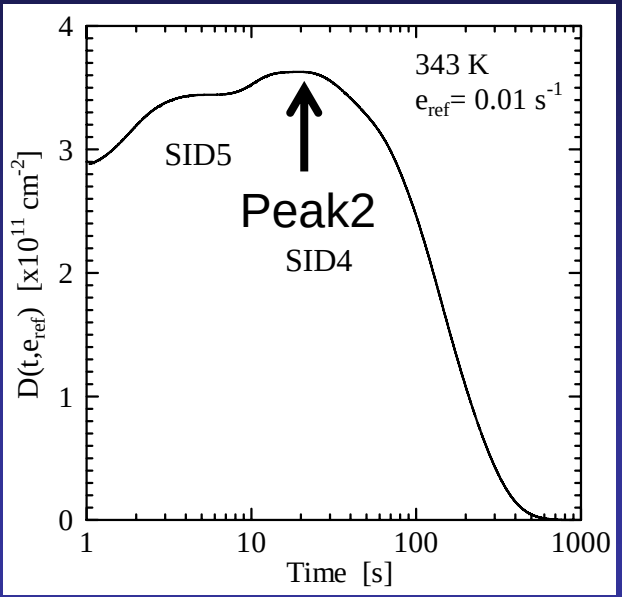
Transient Reverse Current

DCTS signal $D(t, e_{ref}) \equiv t[i(t) - i_s] \frac{\exp(-e_{ref} t + 1)}{qS}$

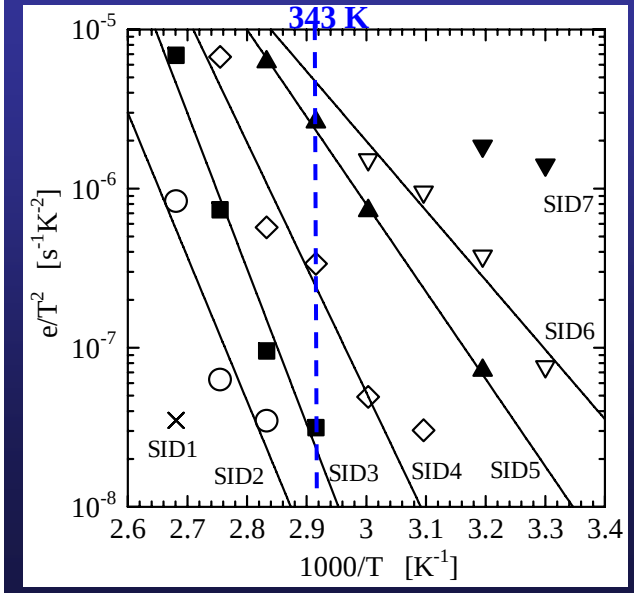
$D(t,0)$ $D(t,0.01)$







Arrhenius Plots



Relationship between emission rate and temperature $e_{ti} \propto T^2 \exp\left(-\frac{\Delta E}{kT}\right)$

Activation energies obtained from Arrhenius plots

Intrinsic defects	SID2	SID3	SID4	SID5	SID6
Δ E [eV]	1.80	1.94	1.56	1.09	0.87

Summary

It was elucidated that DCTS is applicable to semi-insulating semiconductors. DCTS could determine the densities and emission rates of intrinsic defects in high-purity semi-insulating 4H-SiC. From the temperature dependence of the emission rate of each intrinsic defect, its energy level could be determined.

Reference 1) H. Matsuura et. al: JAP 91 (2002) 2085-2092