Recent results on bistable cluster related defects

E. Fretwurst[1] A. Junkes[1] L. Makarenko[3] I. Pintilie[1,2]

[1]Institute for Experimental Physics - Detectorlab
University of Hamburg, Germany

[2]NIMP Bucharest-Magurele, Romania

[3]Belarusian State University, Minsk, Belarus

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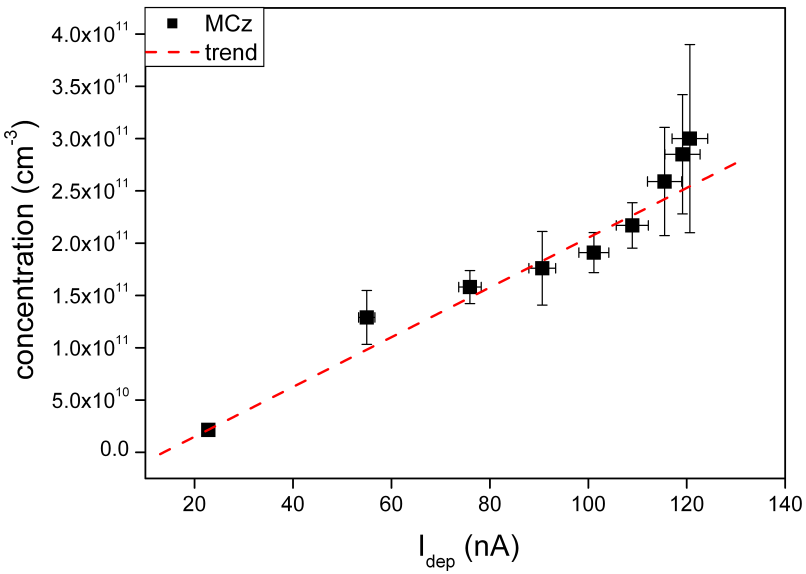
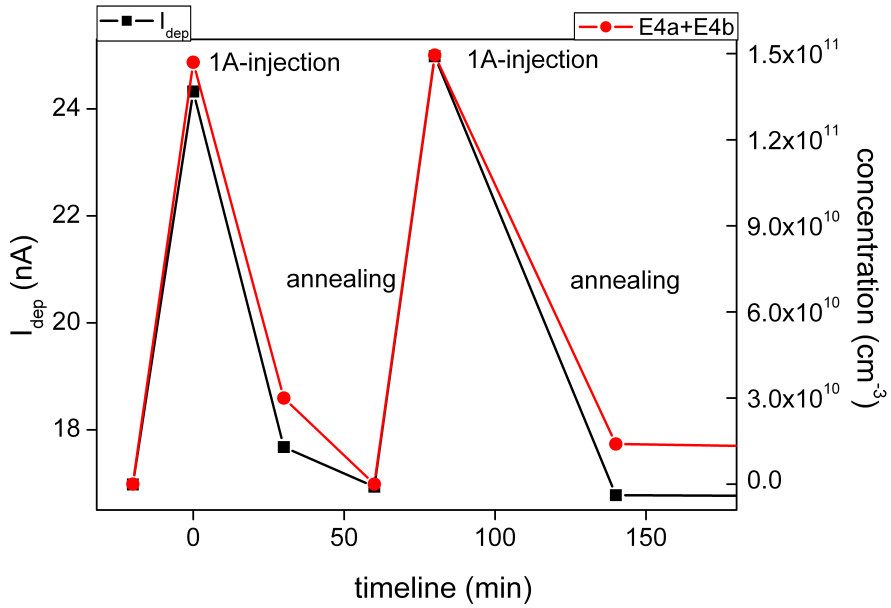
Why investigate cluster related defects?

Cluster related defects are responsible for high leakage current after hadron irradiation

Their structure is still unknown



$E4a + E4b + E205a$ correlated with I_{dep}



switching 'on' and 'off' of I_{dep} and $E4a + E4b$

Materials

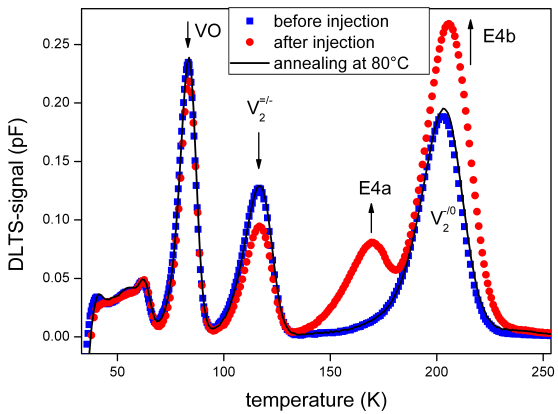
Material	EPI-DO	MCz	FZ	EPI-ST
$N_{Ox.}[10^{16} cm^{-3}]$	66	22	1.8	9.3
Thickness [μm]	74	100	100	74
Irradiation	proton	neutron	proton	proton
Fluence [cm^{-2}]	1.6×10^{13}	3×10^{11}	1×10^{12}	1.6×10^{13}
Method	TSC	DLTS	DLTS in progress	TSC in progress

Bistability of *E4a* and *E4b*

Bistability used to track cluster defects at high T

- observation so far: *E4a*/*E4b* anneal out in 120 min at 80 °C
- novelty: bistability reproducible up to more than 300 °C

DLTS after injection



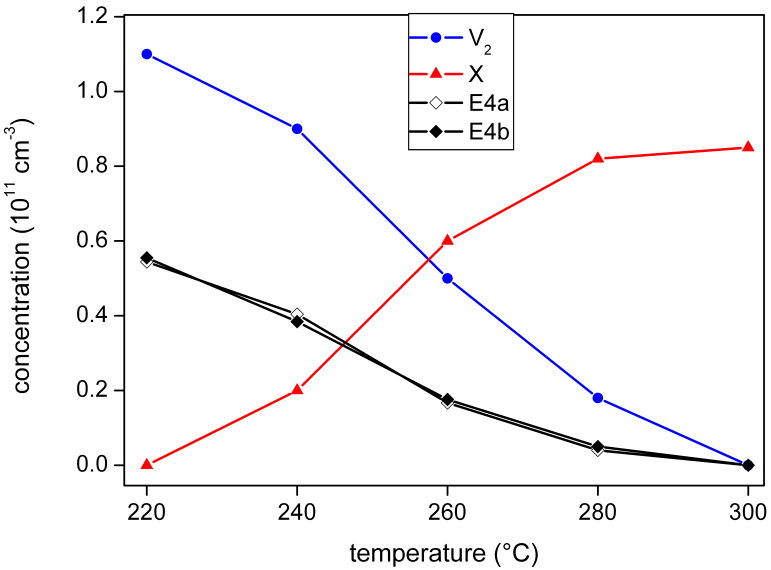
Annealing procedure

1. isochronal annealing step
2. injection of 1A
3. isothermal annealing (80 °C)

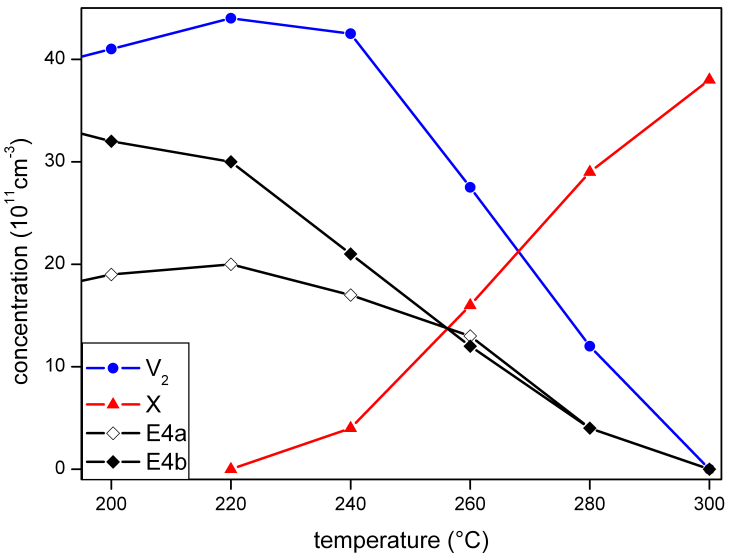
measurements: CV/IV, DLTS/TSC, charge capture

Annealing behaviour - oxygen rich material

MCz - neutron irradiated (DLTS)



oxygen enriched Epi - proton irradiated (TSC)

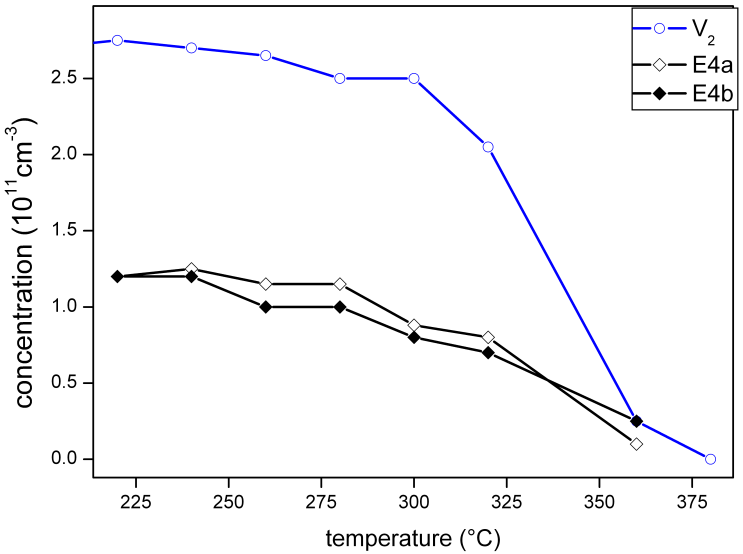


Simultaneous annealing out of *E4a*/*E4b* and the divacancy

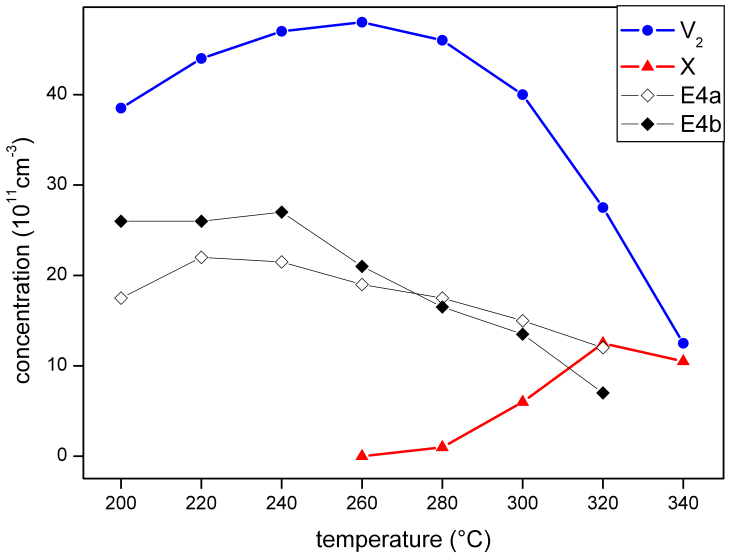
→ supports the assumption that *E4a*/*E4b* are vacancy like

Annealing behaviour - oxygen lean material

FZ - proton irradiated (DLTS)



Epi-St - proton irradiated (TSC)



Annealing in progress, similar results expected

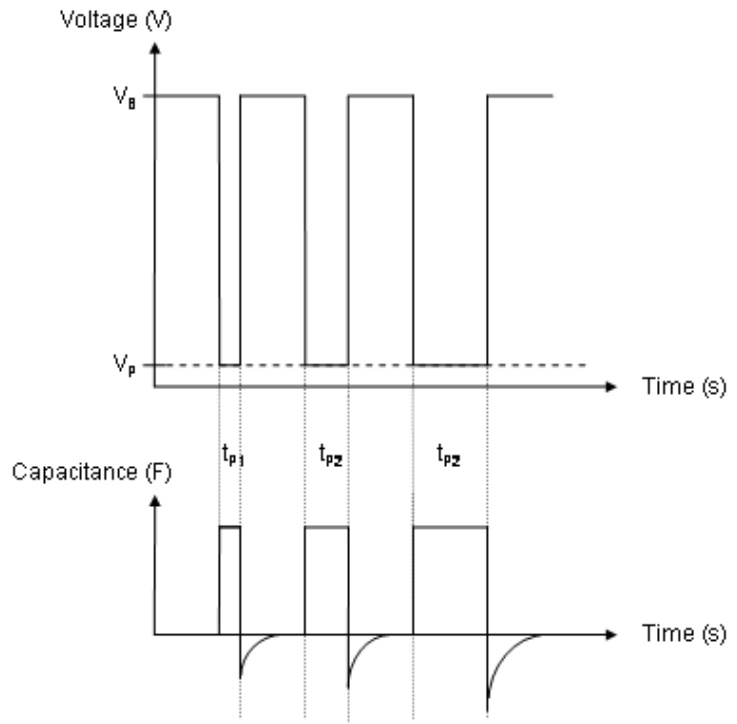
Low oxygen content $\rightarrow$ annealing of $E4a/E4b$ and V_2 delayed

Basics

- capture and emission probability of defects described by SRH-statistics
- depending on $\sigma_{n,p}$ and E_a
- TSC - measurement of current during charge carrier emission
- DLTS - measurement of capacitance transients

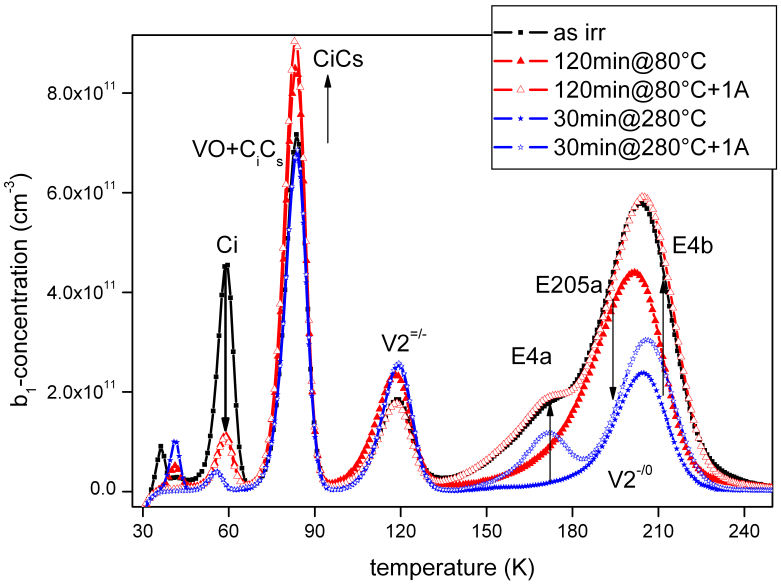
$\Rightarrow$ charge capture characteristics very important!
$\Rightarrow$ $\sigma_{n,p}$ by DLTS capture measurements at fixed temperature

capture measurements

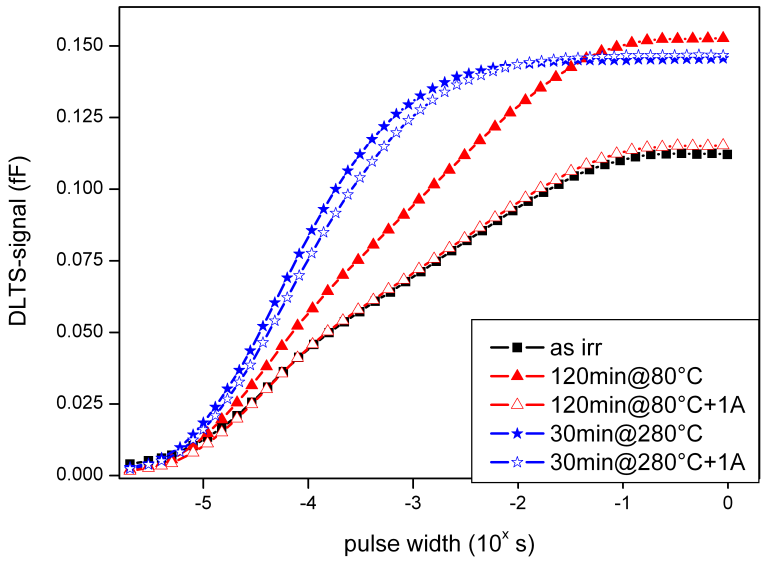


Cluster defects influence point defects signals ($V_2^{=/-}$)

FZ - proton irradiated (DLTS)



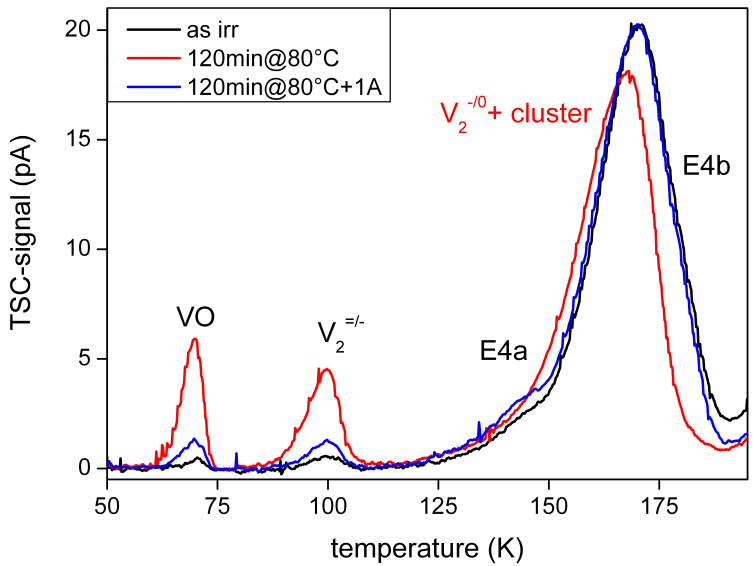
capture measurement on $V_2^{=/-}$



- cluster influence filling time and signal height of $V_2^{=/-}$
- measurement of σ_n influenced by cluster related defects

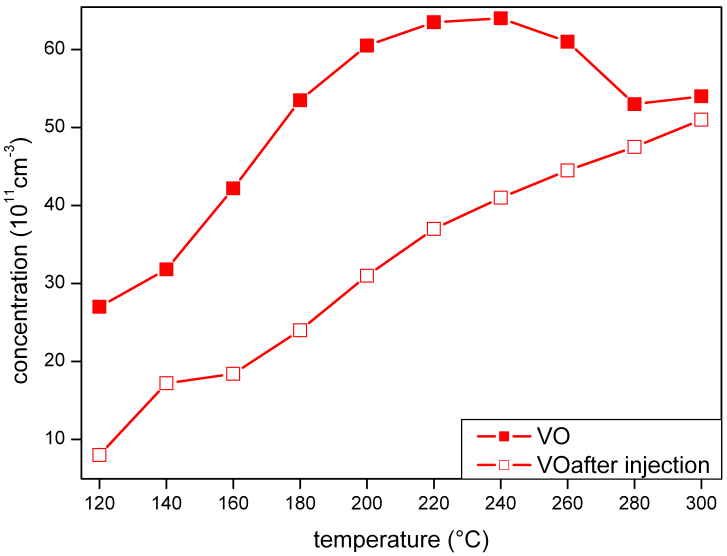
VO and $V_2^{-/0}$ influenced by cluster related defects

TSC-spectra (EPI-ST)



- measured concentrations influenced by clusters
- $V_2^{-/0}$ reduced, as well!

Preliminary *VO*-annealing (EPI-DO)



- annealing curve of *VO* not understood
- introduction rates?

What may lead to the reduction

Speculations

- cluster related defects are multiple vacancies
- location of point defects inside and outside the disordered regions has important impact $\rightarrow$ comparison of neutron and proton irradiation

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More speculations

- potential walls to overcome by charge carriers due to electrical shielding
- explanation by lattice strain distortion problematic
- no formation of 'new' defects, change of visibility

Summary & outlook

summary

- Annealing of V_2 and $E4a/E4b$ similar
- Supports the assumption that $E4a/E4b$ are vacancy related
- Cluster defects influence the measured σ_n and signal of point defects

outlook

- Finish measurements, confirm observation on samples with high oxygen content
- More detailed evaluation of capture measurements