

Detailed studies on the E4/E5-defect as main current generator

Alexandra Junkes¹, Eckhart Fretwurst¹, Ioana Pintilie²
and Gunnar Lindström¹

¹Institut für Experimentalphysik, Hamburg University

²NIMP, Bucharest-Margurele

16th RD50 Workshop
31.05-02.06.2010, Barcelona



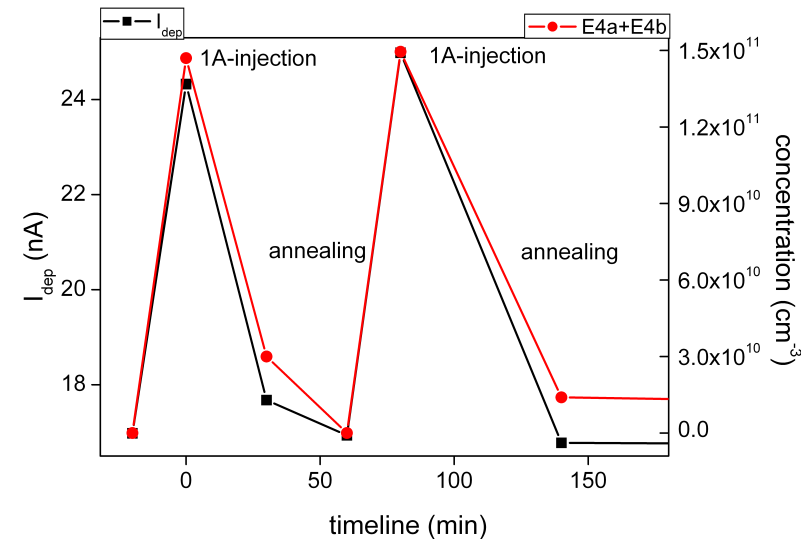
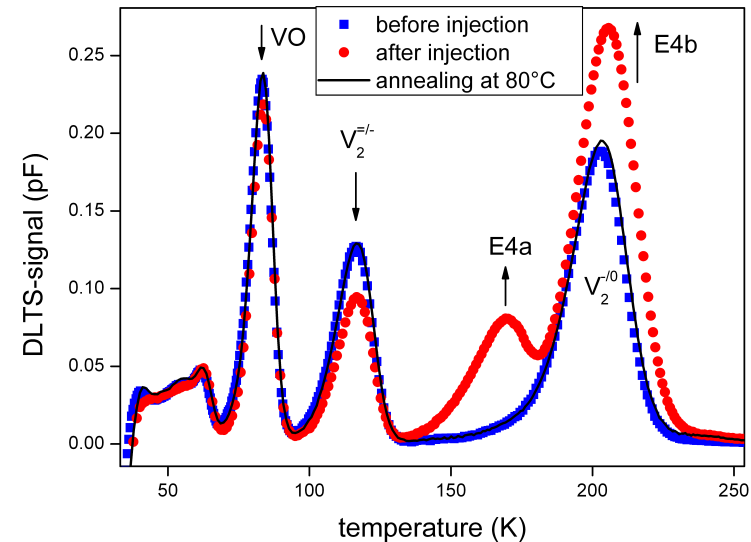
Why is E4/E5 interesting?

- E4/E5 is correlated to LC
- Bistability found on E4/E5
- Now traceable up to more than 300°C

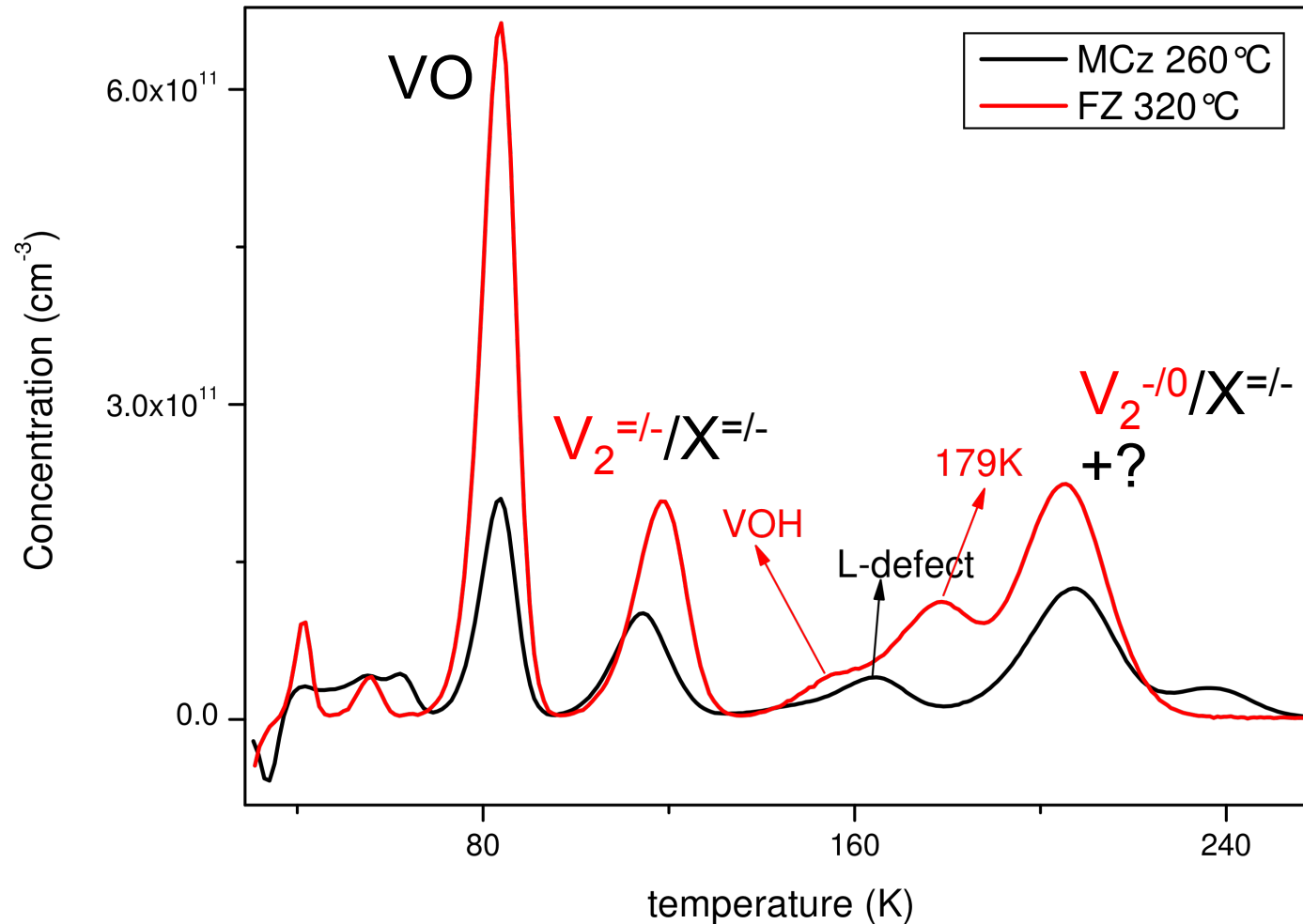
- 1) What type of defect is E4/E5?
- 2) How much impact on LC?

- Using bistability one can track the transformation to L-defect

- Annealing behaviour like V_2
 → Vacancy related (maybe V_3)



L-defect appears in oxygen rich material

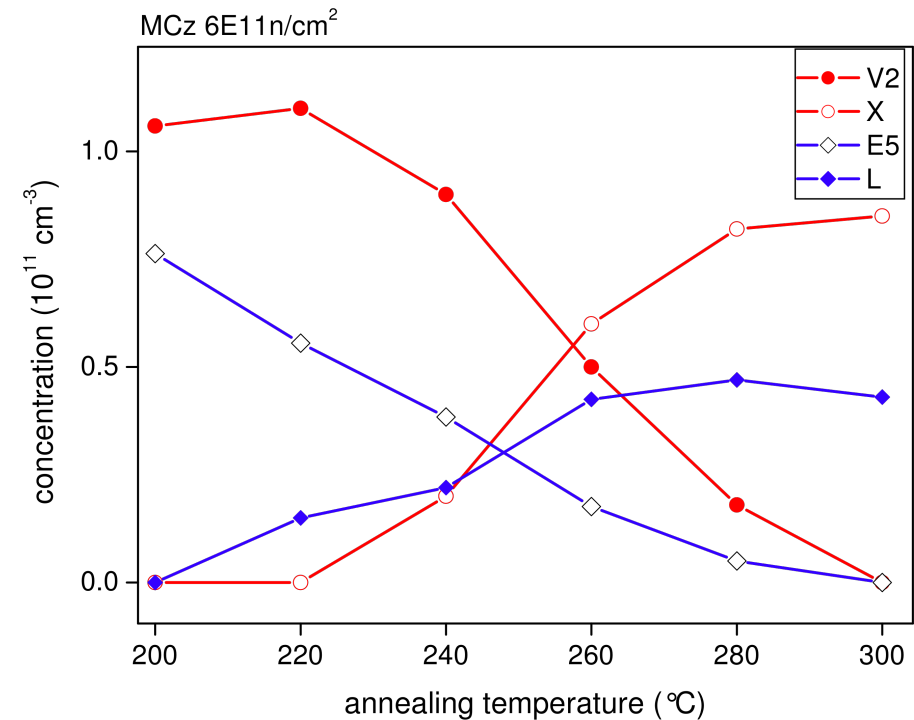
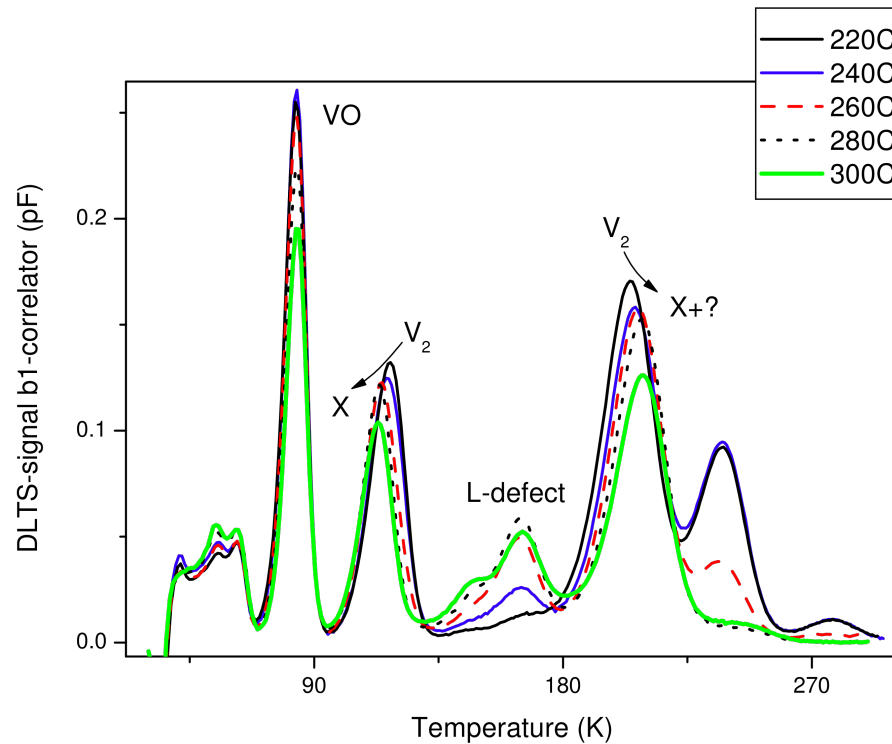


$$[O_{\text{FZ}}] \approx 10^{15}$$

$$[O_{\text{MCz}}] \approx 10^{17}$$

No L-defect in FZ material!

Transformation of E4/E5 to L in MCz



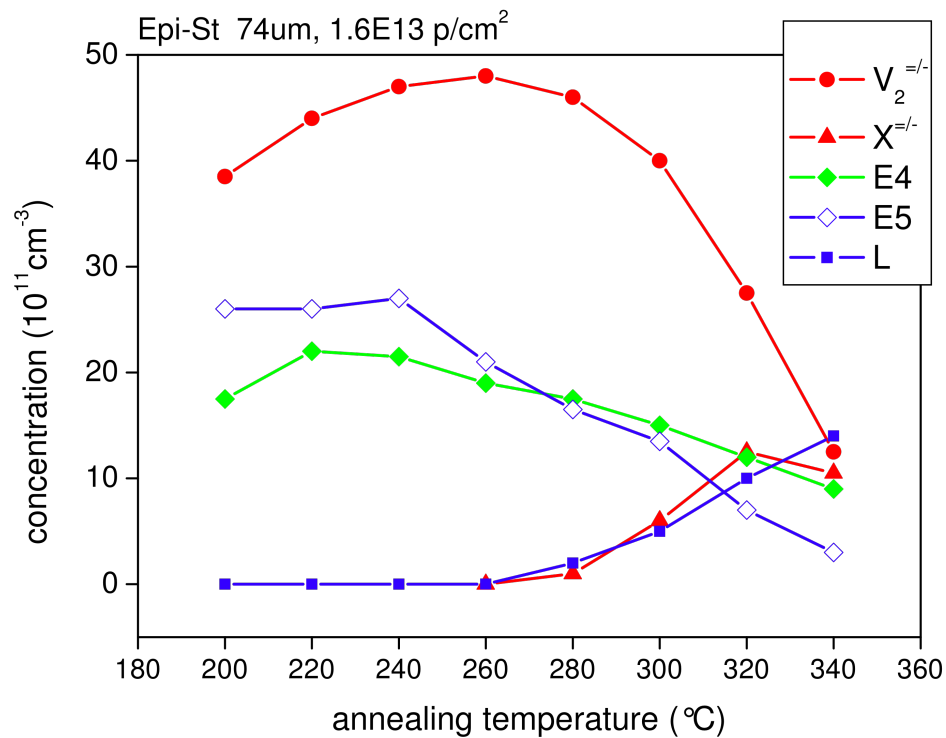
E4/E5 to L behaves like $V_2 \rightarrow V_2O$



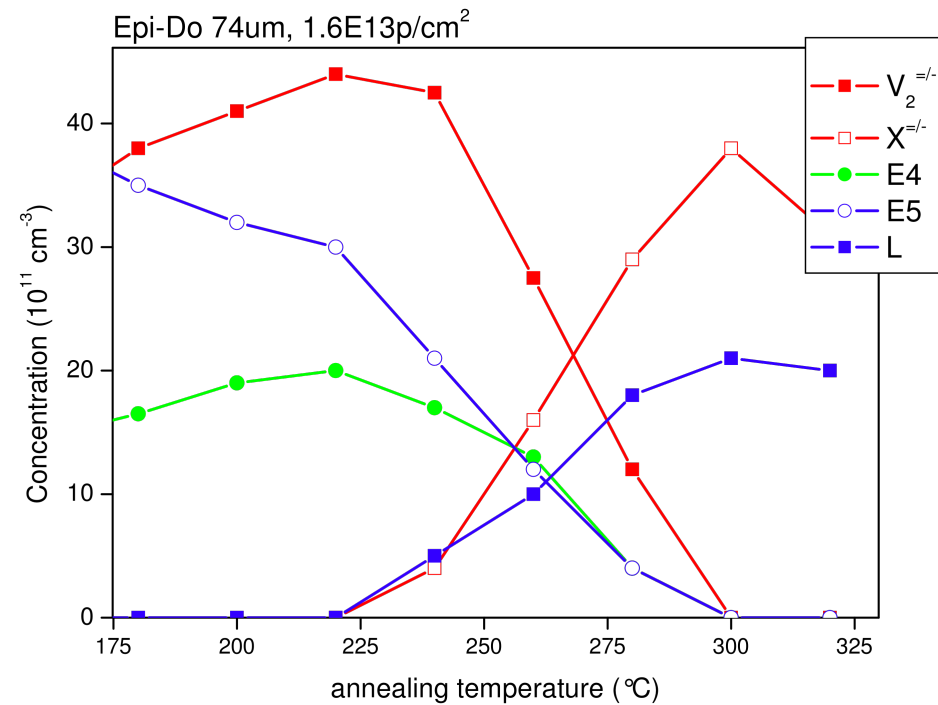
$V_3 \rightarrow V_3O$

Transformation from E4/E5 to L-defect

Epi-ST



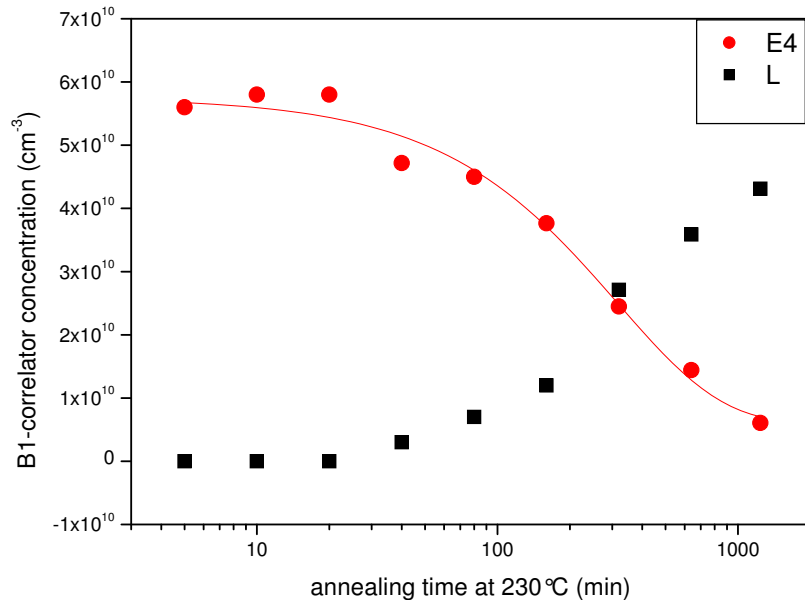
Epi-DO



Similar observation in Epi but delay for oxygen lean material

V₃ Activation Energy for Migration

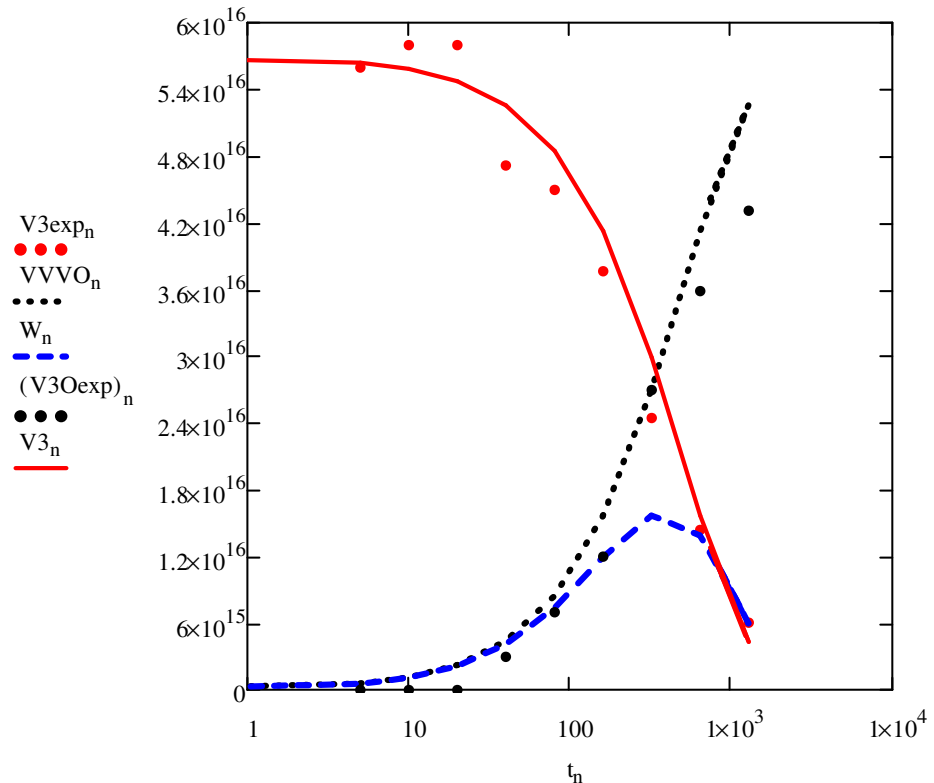
DLTS, Epi-Do, neutrons



Annealing temperatures:

- 230°C
- 240°C
- 250°C

Fitting result



$$E_a = 1.245 \text{ eV}$$

$$(D_{V_3}^* = 2.2 \times 10^{-6} \text{ cm}^2 \text{ s}^{-1})$$

*Pichler 2004

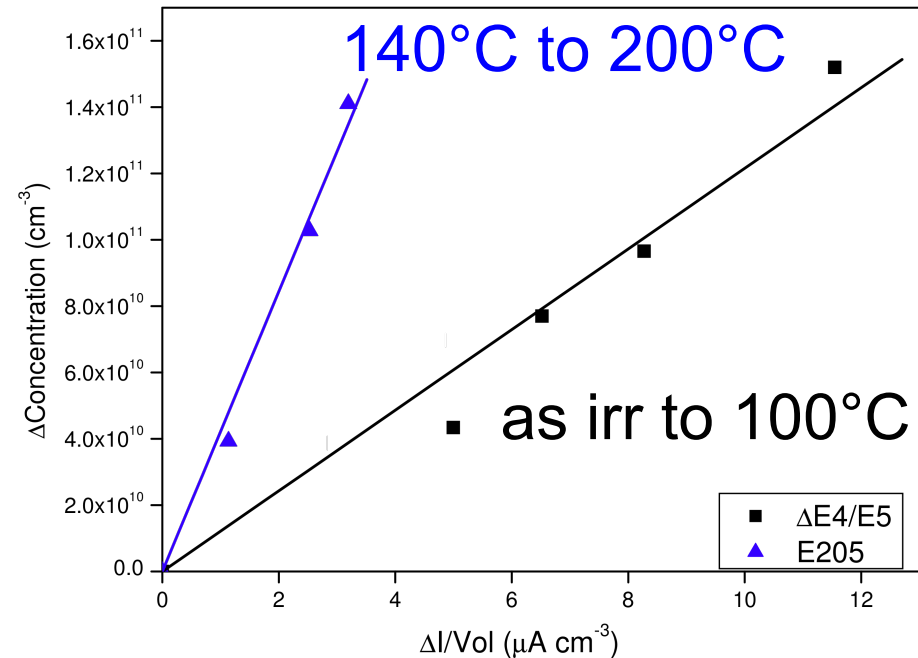
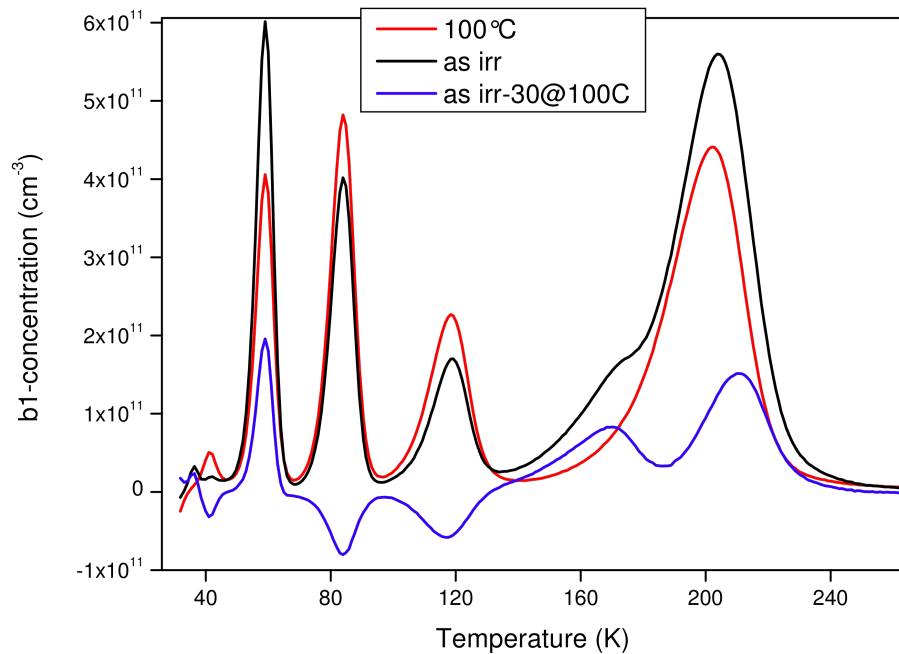
Short Summary

- Annealing of E4/E5 traceable with help of bistability
- E4/E5 transforms to L-defect
- Similar annealing behaviour like V_2 to X-defect (V_2O)
- If E4/E5 is V_3 than L is most likely V_3O

Correlation of LC to E4/E5 & E205a

Via difference spectra

Correlation for Epi-St 100um

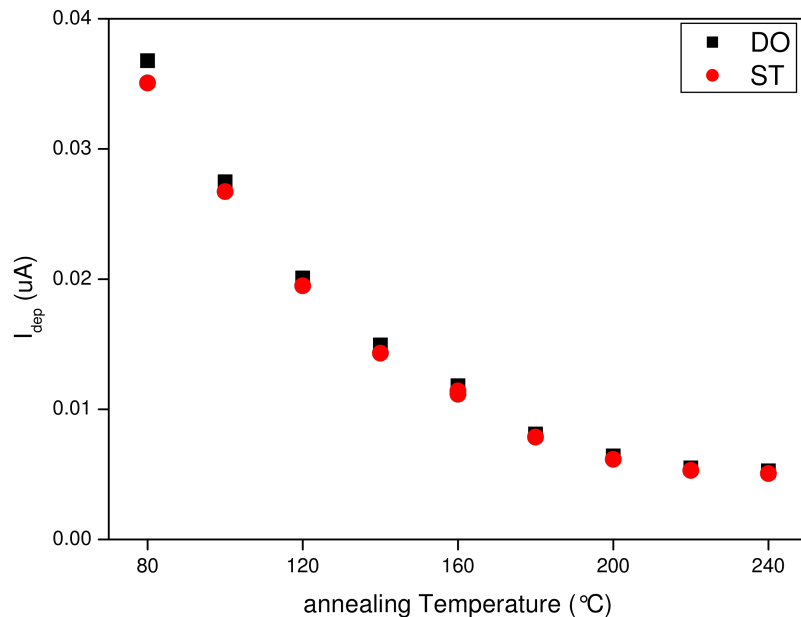


Low fluence proton irradiation

E4/E5 hole capture:
 $\sigma_h \approx 10^{-13} \text{ cm}^2$

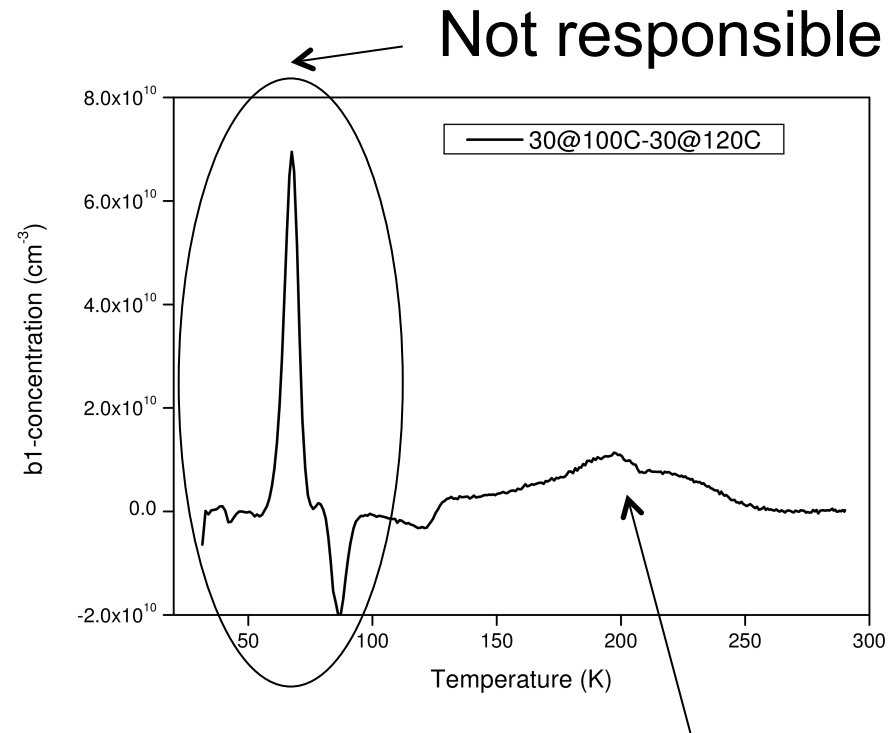
But what happens between 100°C and 140°C?

Leakage Current



Similar LC annealing for
Epi-St and Epi-DO

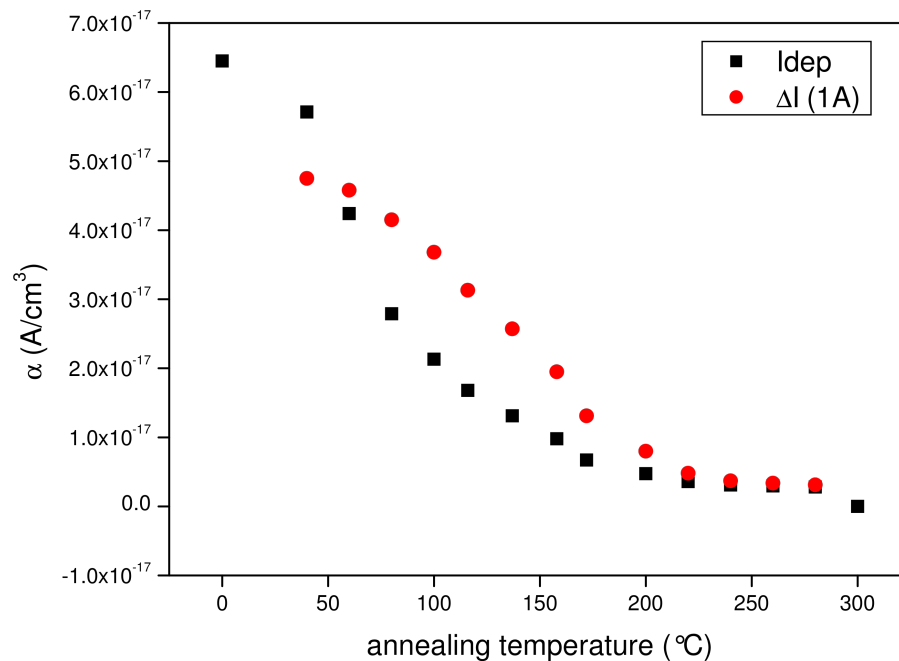
Annealing (100°C-120°C)



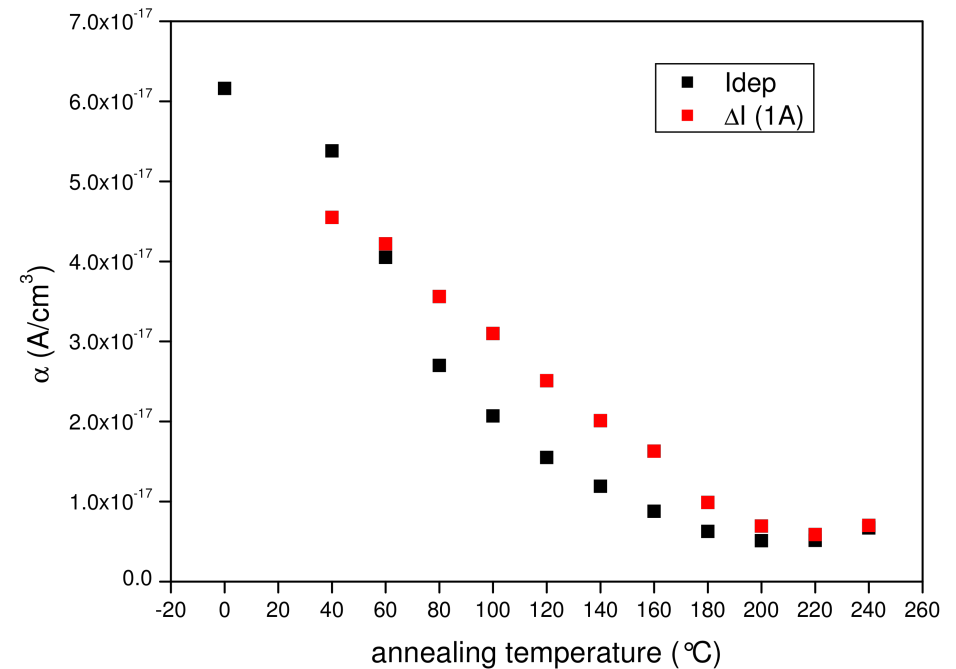
Very low concentration
 $\approx 10^9 \text{ cm}^{-3}$

Recovery of LC during isochronal annealing

In FZ



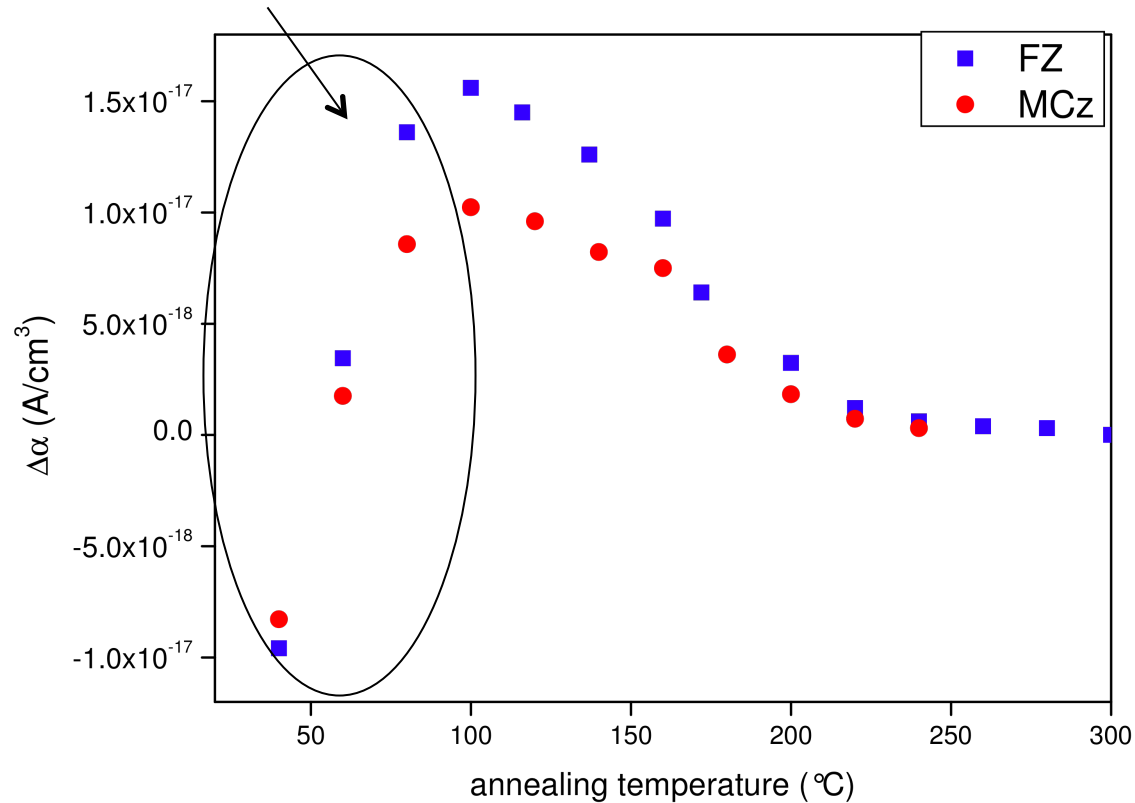
In MCz



Recovery decreases, while E4/E5 is still fully recovered

E4/E5 not solely responsible for LC

Annealing due to heating?



Similar behaviour in FZ and MCz

➔ no oxygen dependence

Relaxation of disordered region may lead to Change of :

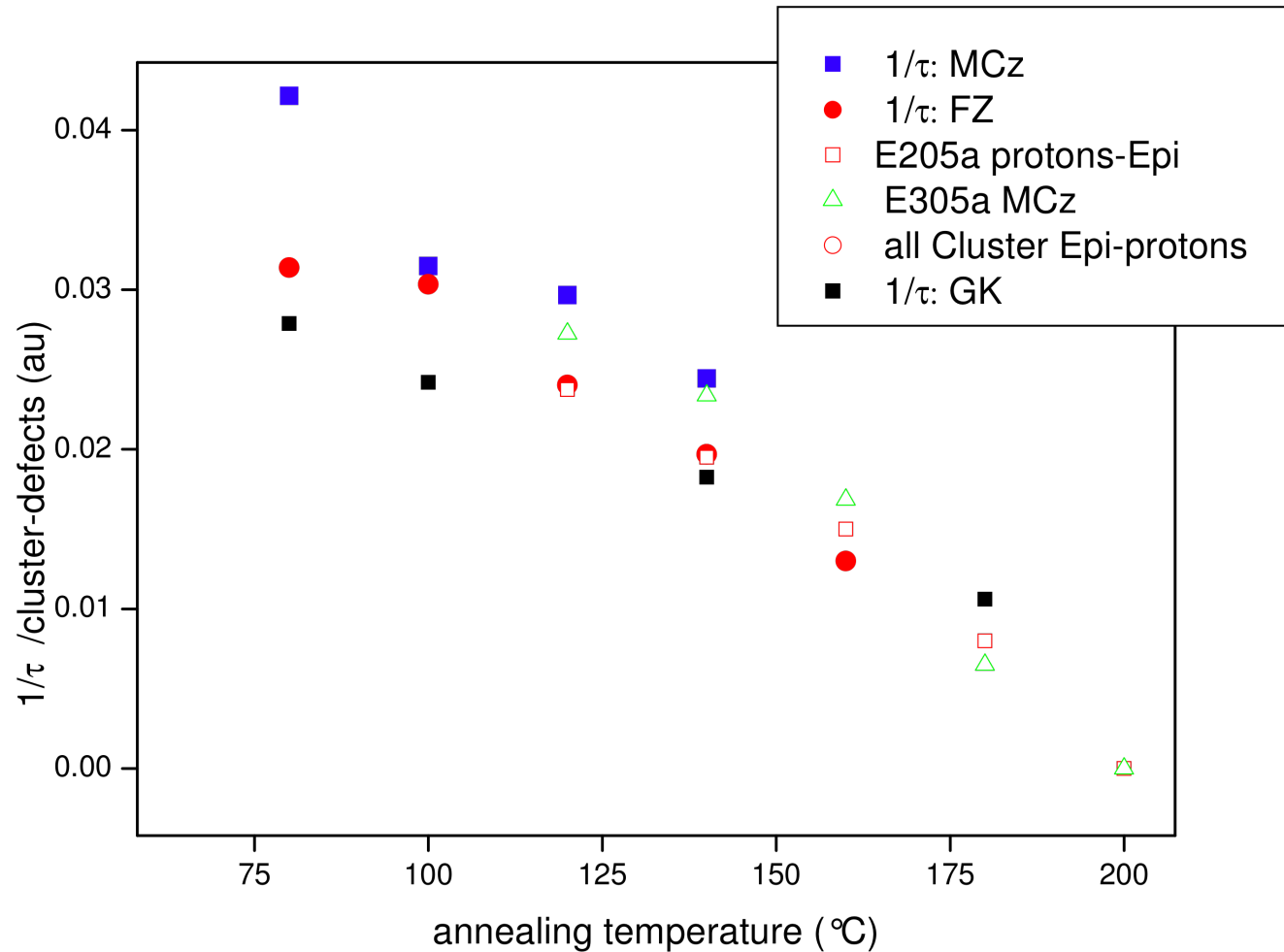
Intercenter charge transfer / lattice strain

Summary

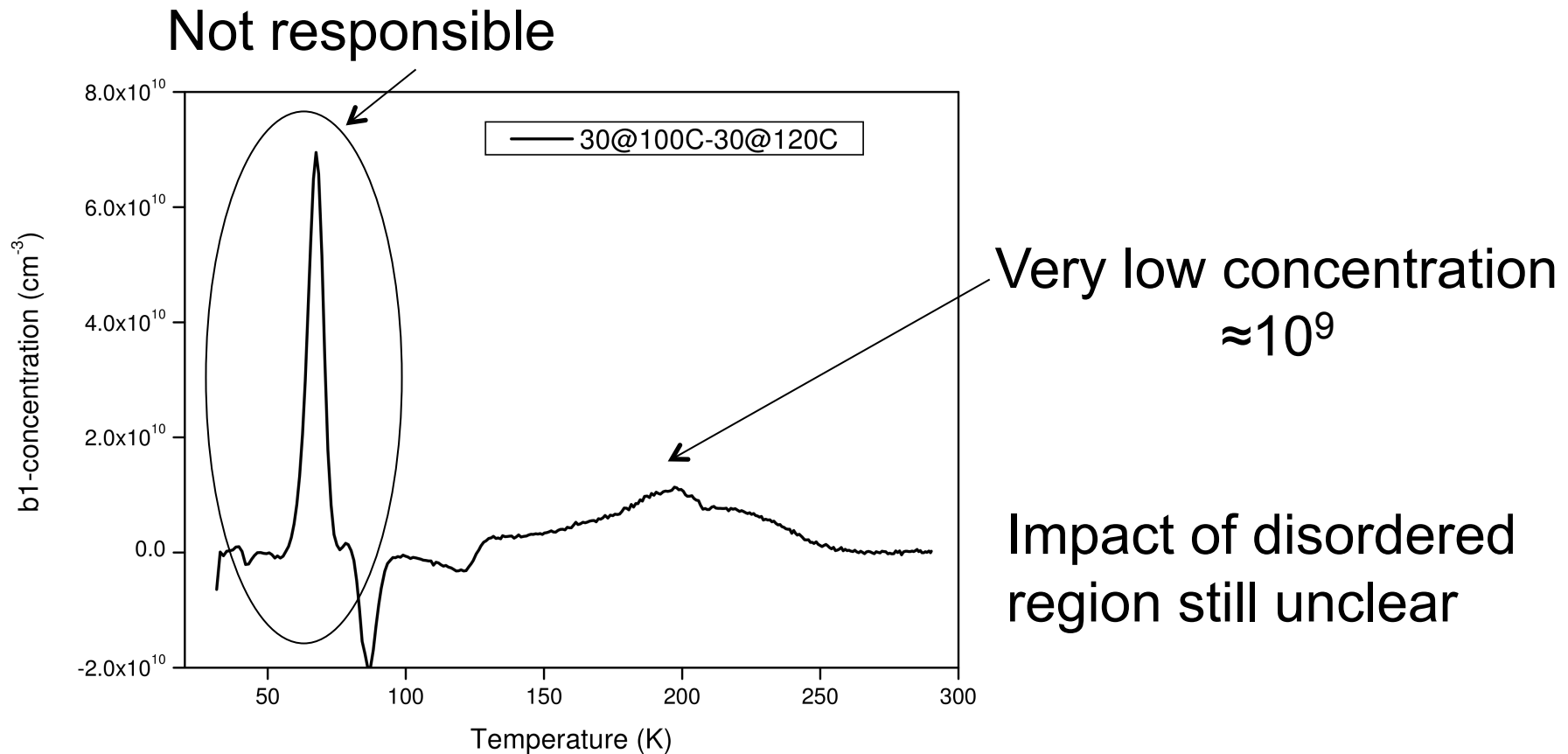
- Correlation between E4/E5 and LC found
- No explanation for decrease of LC between 100°C and 140°C
- Recovery of the LC due to recovery of E4/E5 decreases
- Reorientation of disordered region has impact on LC and E4/E5
- E4/E5 a tracker for initial annealing of the disordered region

Outlook

Origin of electron trapping – E205a?



Origin of LC annealing?



No explanation due to defect seen in DLTS