DLTS measurements of Epitaxial and MCZ silicon detectors after 26 MeV proton irradiation

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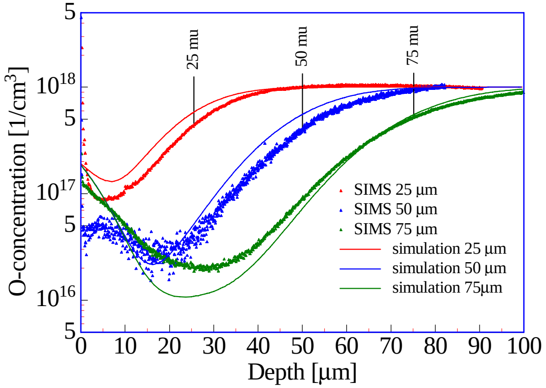
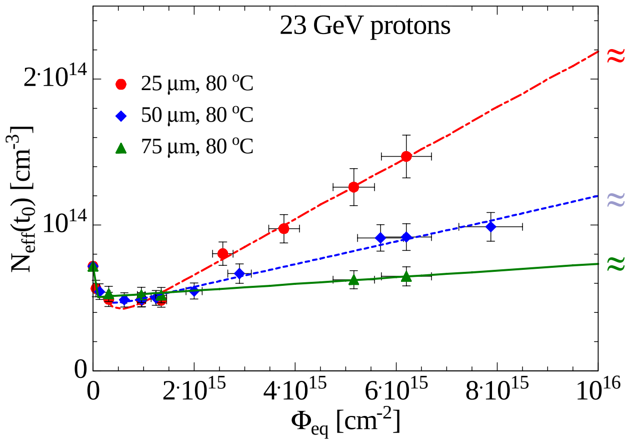
Outline

- Motivation
- Material properties
- Experimental methods
- Measurements and results
- Conclusions

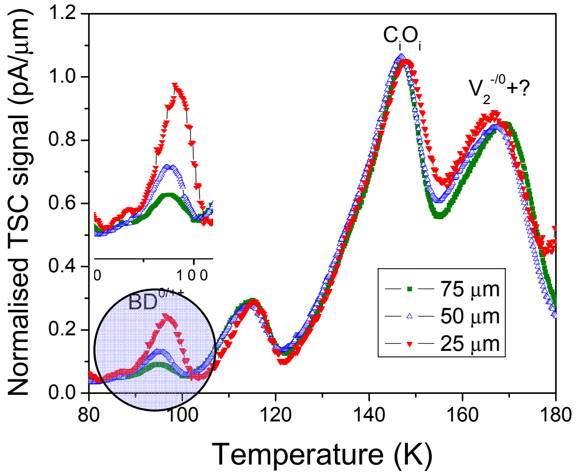
Shallow Donors, the real issue for EPI

-Comparison of 25. 50 and 75 um Diodes-





Defect spectroscopy after PS p-irradiation



Generation of shallow donors BD (Ec-0.23 eV) strongly related to [O] Possibly caused by O-dimers, dimers monitored by IO_2 complex

SIMS profiling:

[O](25µm) > [O](50µm) > [O](75µm)

Stable Damage:

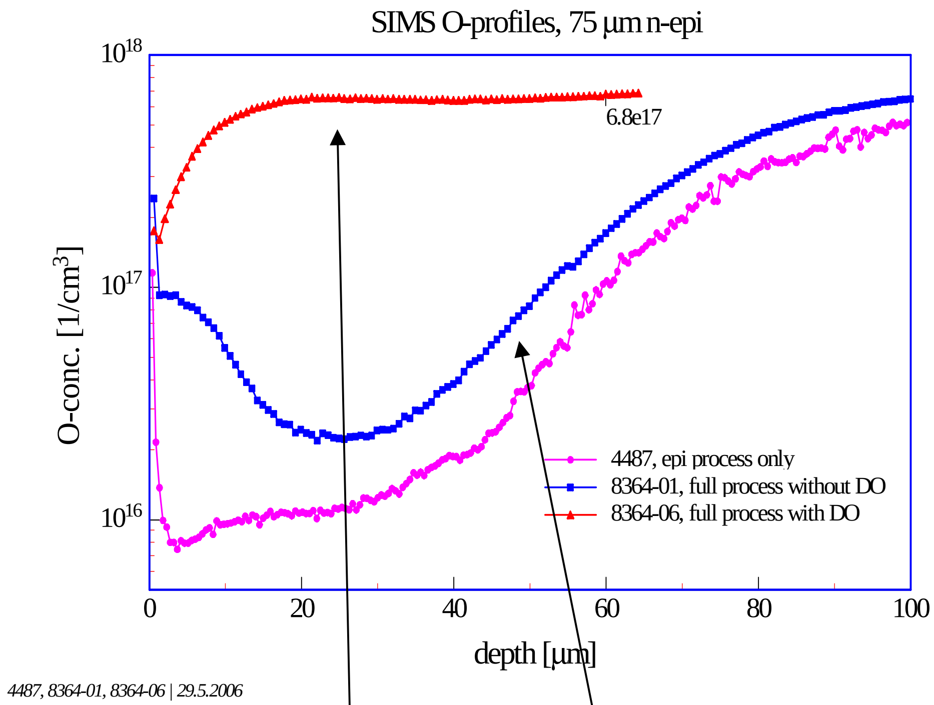
N_{eff}(25µm) > N_{eff}(50µm) > N_{eff}(75µm)

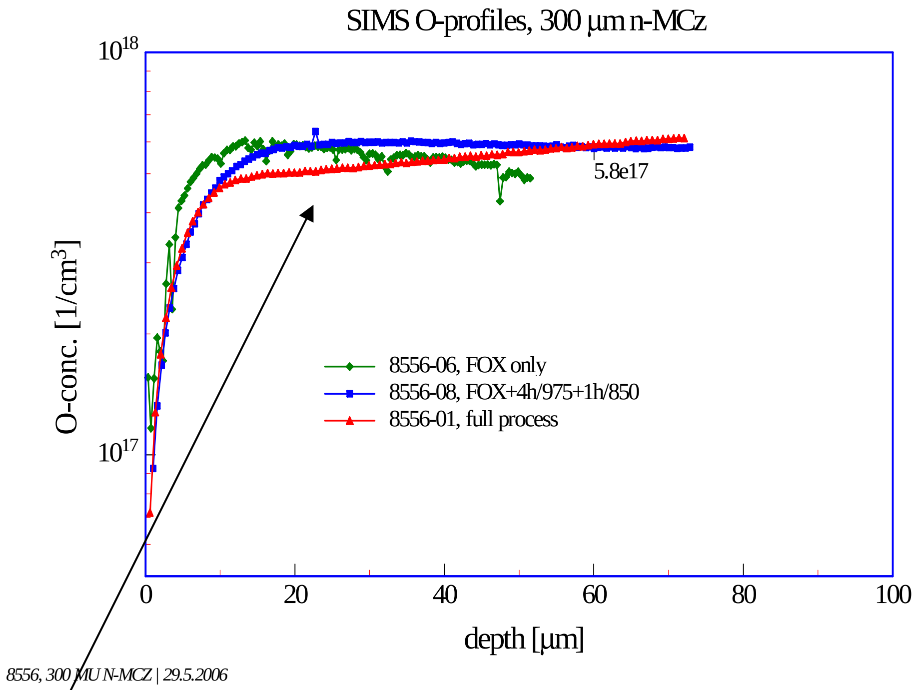
TSC Defect Spectroscopy:

[BD](25µm) > [BD](50µm) >[BD](75µm)

Strong correlation between [O]-[BD]-g_C
generation of O (dimer?)-related BD reason for superior radiation tolerance of EPI Si detectors

Material





Epi/Cz: n-type, 145 Ωcm, 75 µm on 300 µm Cz-substrate, Cis process

(with and without DO)

MCZ: n-type, 880 Ωcm, 300 µm , Cis process

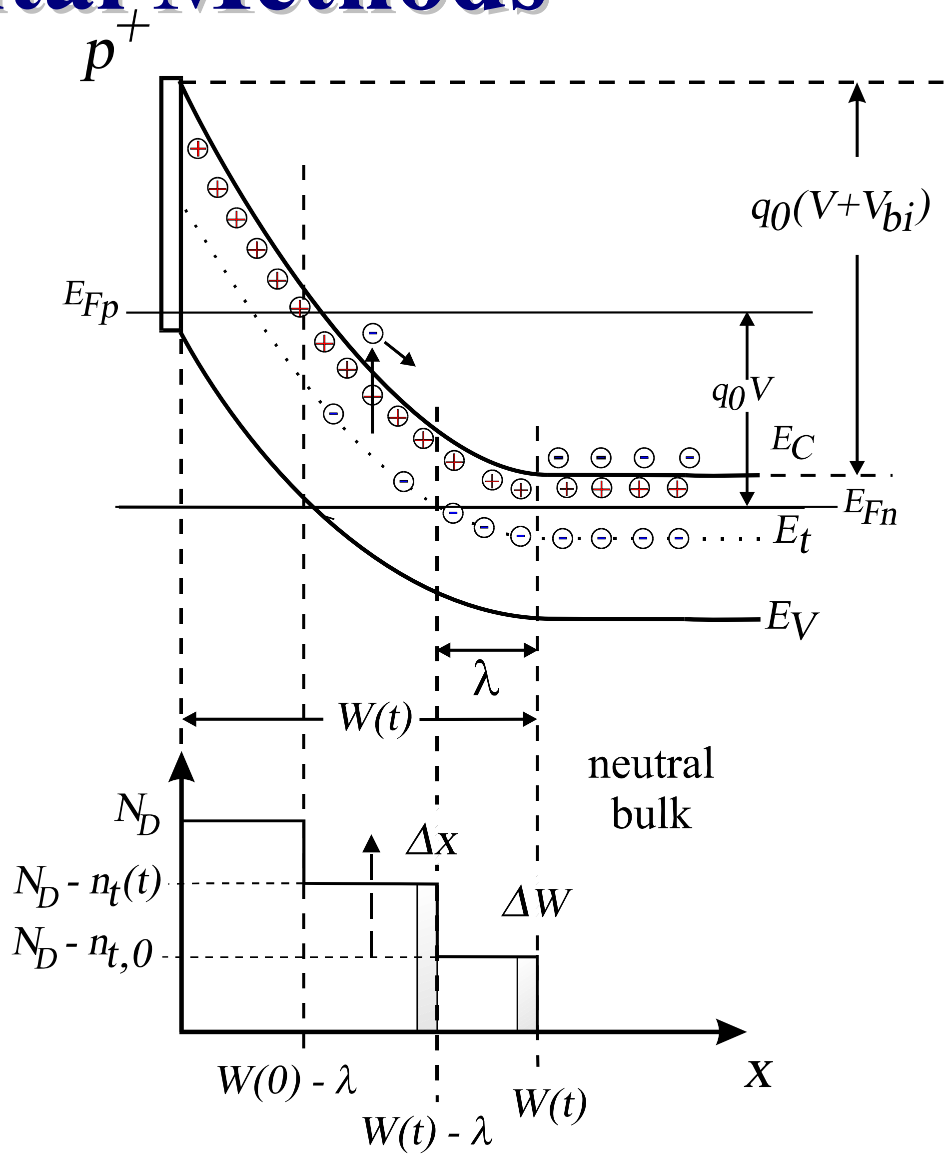
Experimental Methods

Irradiation source:

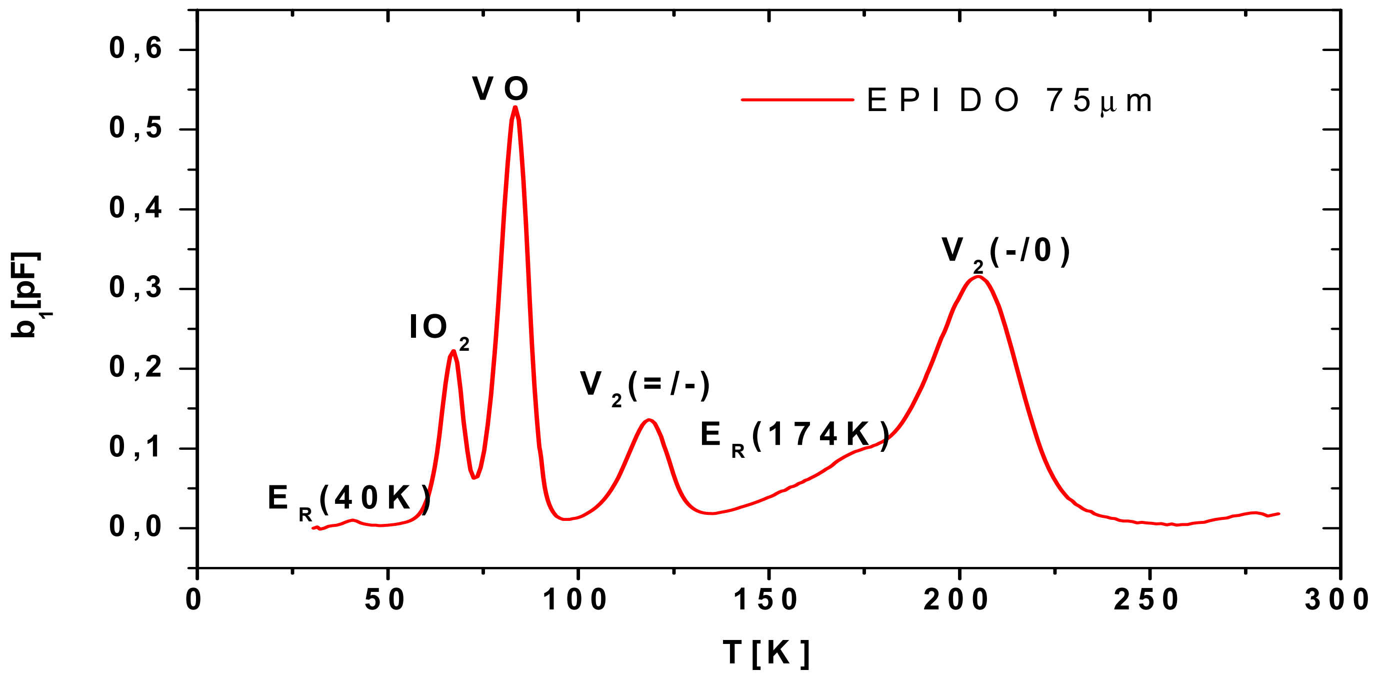
26 MeV protons

- Defect characterisation by C-DLTFS
- Measurement of depth profile taking transition region into account.

$$N_t = 2N_D \frac{\Delta C_0}{C_R}\left[1-\left(\frac{C_R}{C_P}\right)^2 - \frac{2\lambda C_R}{\varepsilon\varepsilon_0 A}\left(1-\frac{C_R}{C_P}\right)\right]^{-1} \approx 2N_D \frac{|\Delta C_0|}{C_R}$$



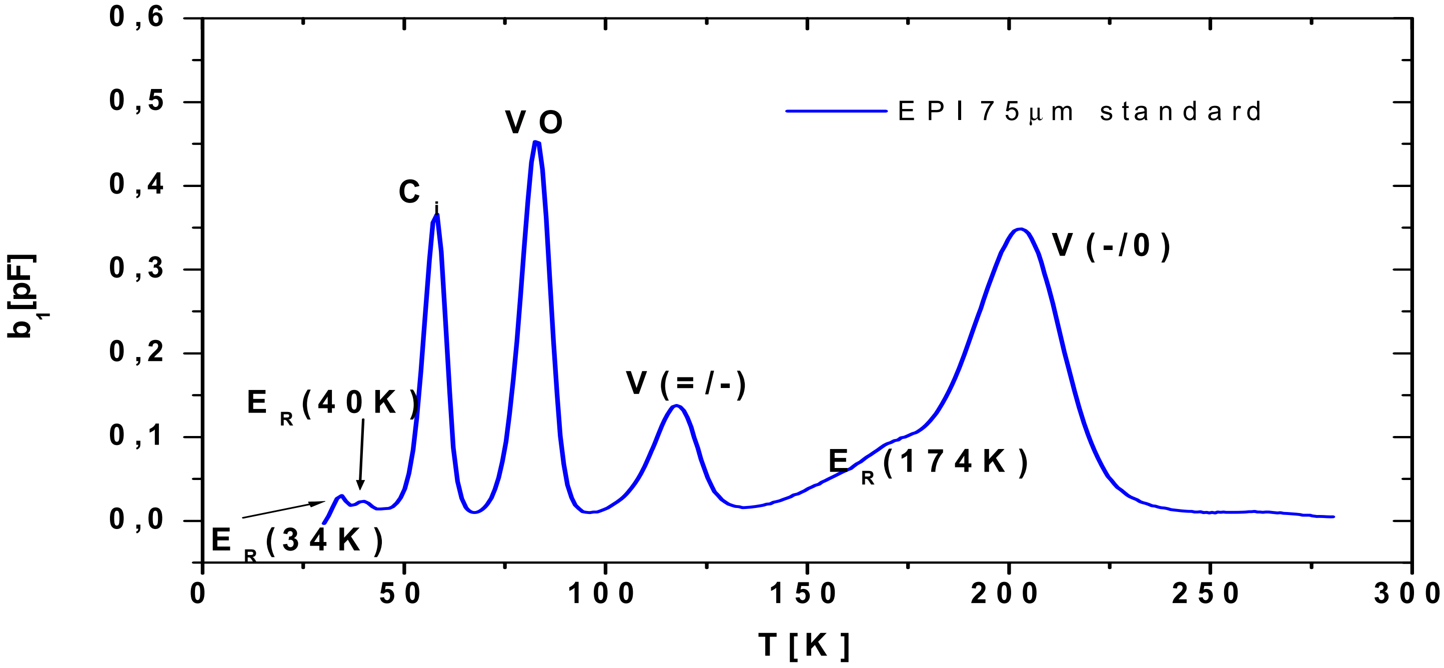
DLTS Spectra



EPI DO:

- Φ_{eq}= 8.2 x 10^{11} cm^{-2} p^{+} 26 MeV
- U_R= -20V, U_P=-0.1V
- T_W= 200ms, T_P= 100ms

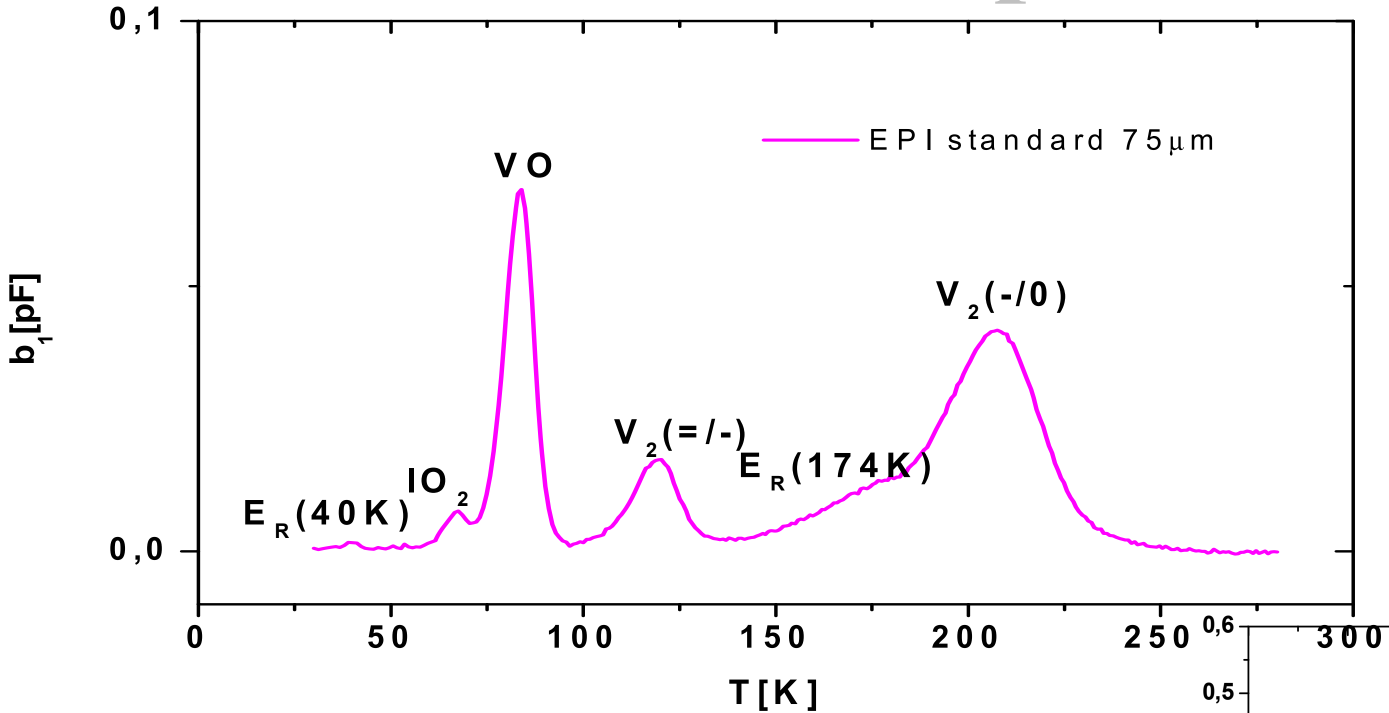
DLTS Spectra



EPI standard:

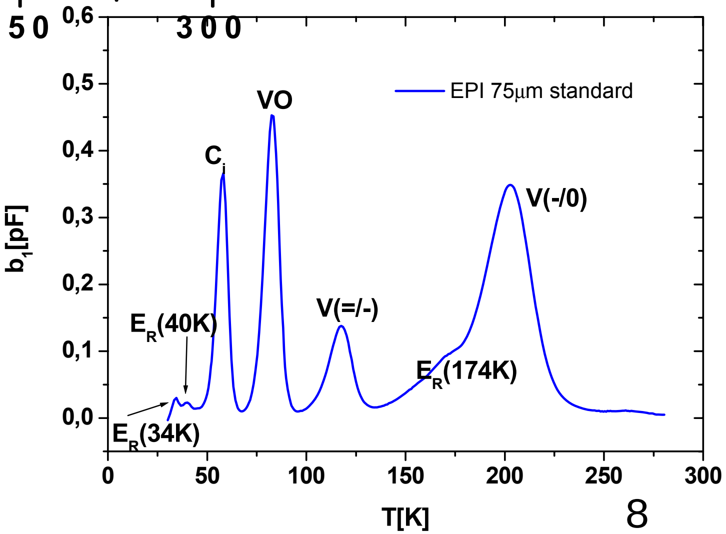
- Φ_{eq}= 8.0 x 10^{11} cm^{-2} p^+ 26 MeV
- U_R= -20V, U_P=-0.1V
- T_W= 200ms, T_P= 100ms

DLTS Spectra

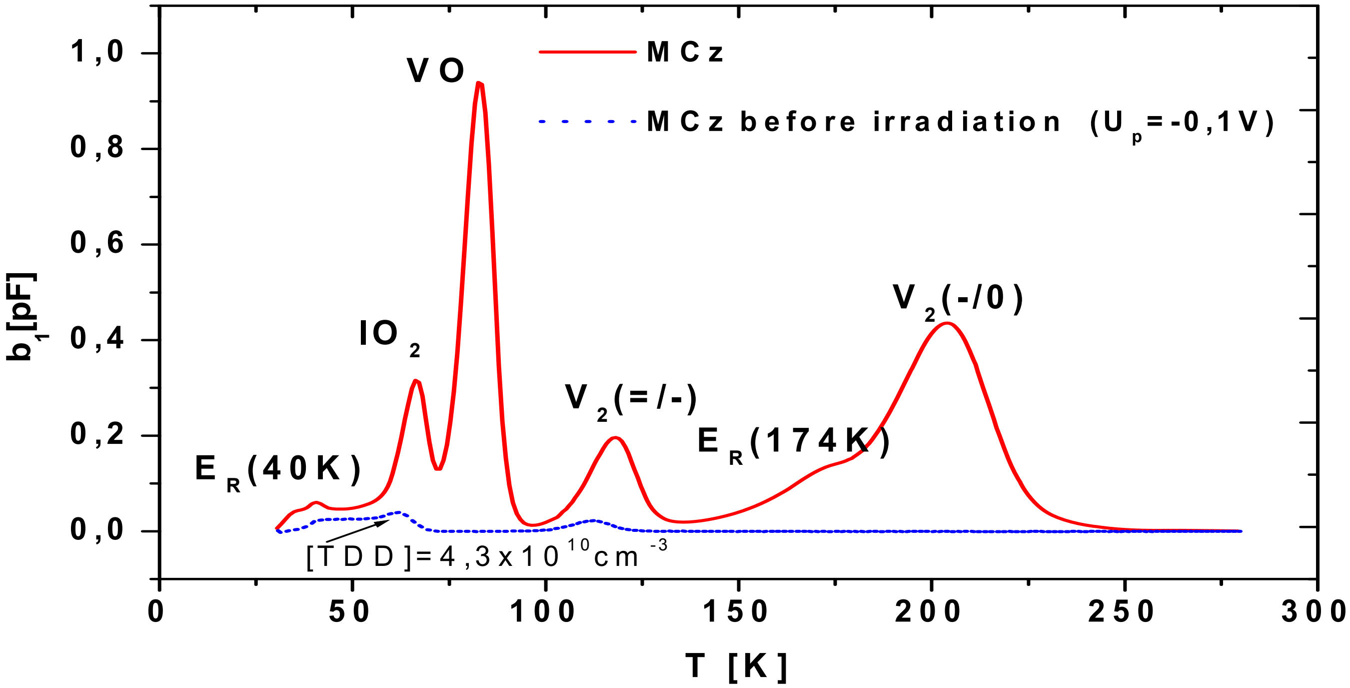


EPI standard (backside):

- Φ_{eq}= 8.0 x 10^{11} cm^{-2} p^{+} 26 MeV
- U_R= -80V, U_P=-60V
- T_W= 200ms, T_P= 100ms



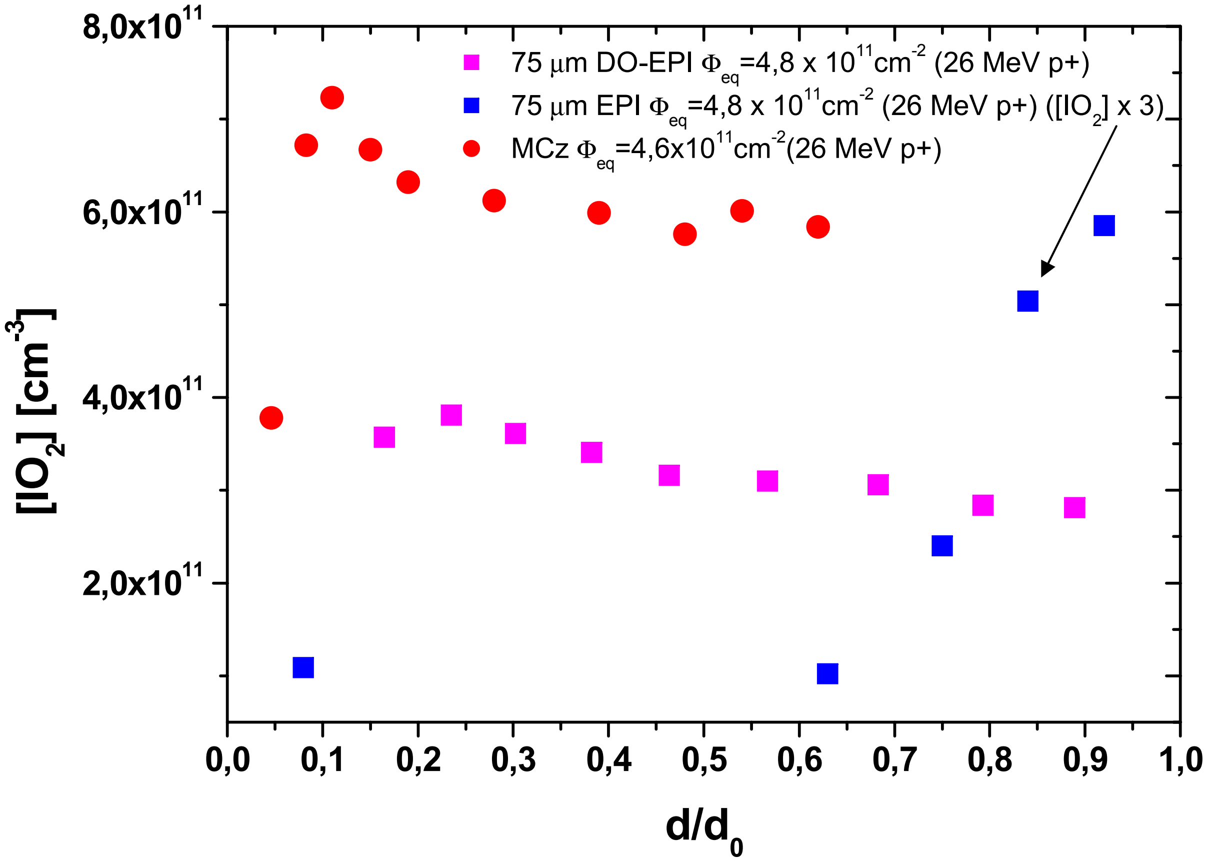
DLTS Spectra



MCZ:

- Φ_{eq}= 4.6 x 10^{11} cm^{-2} p^+ 26 MeV
- U_R= -20V, U_P=-5V
- T_W= 200ms, T_P= 100ms

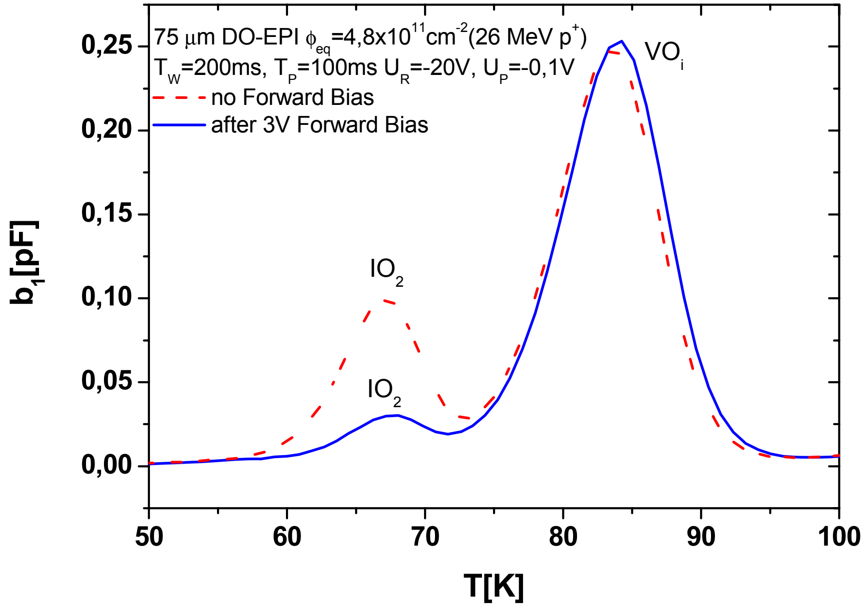
Depth profil IO_2



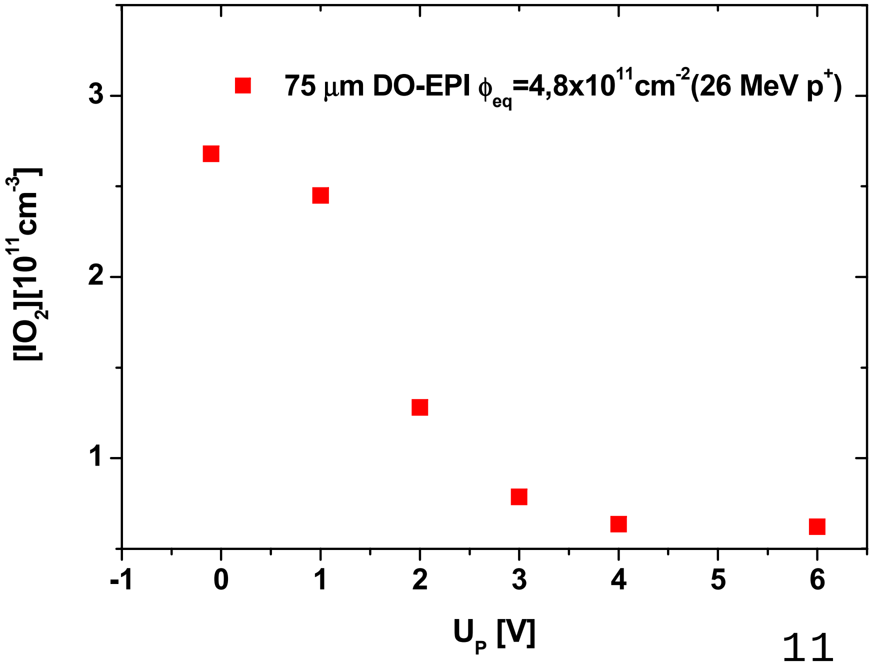
In DO-EPI and MCZ $[IO_2]$ is almost homogeneous like [O]

In EPI standard $[IO_2]$ is strongly inhomo-geneous like [O]

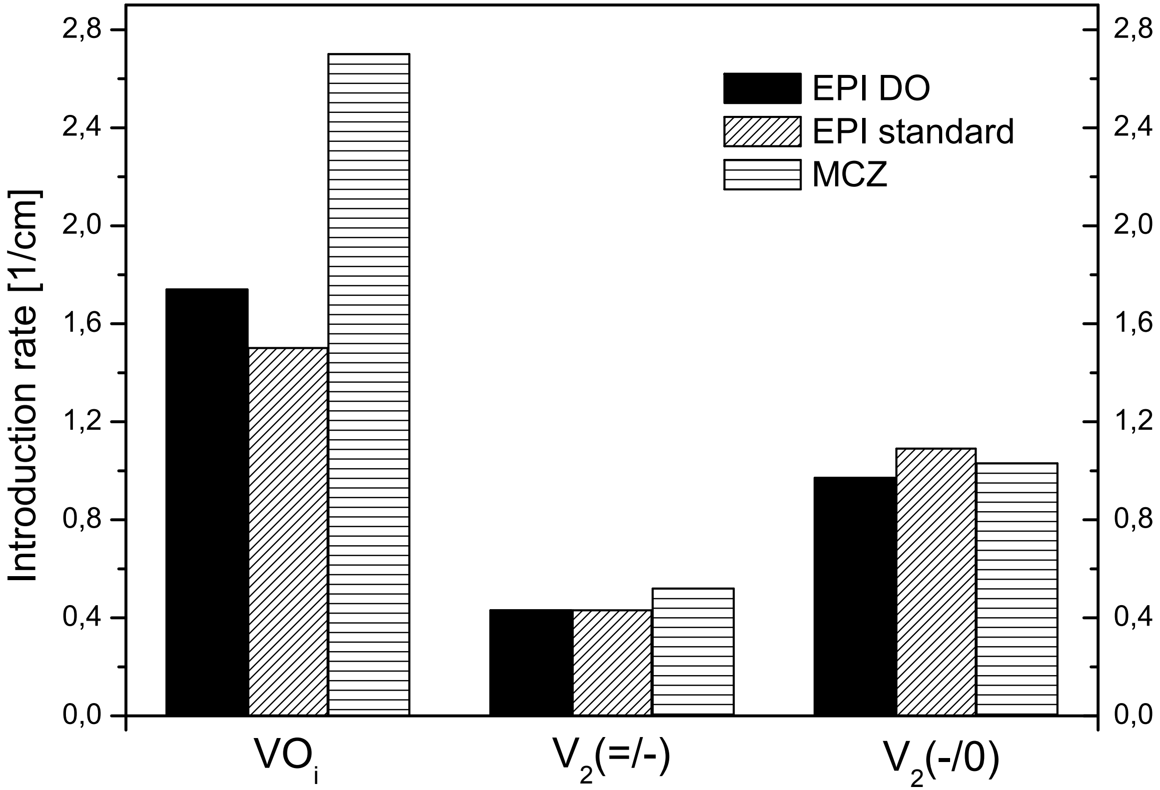
Bistability of IO_2



Change of state by forward biasing



Introduction rates



VO:

Similar introduction rate like for 23 GeV p+ irradiation

MCZ is higher after 26 MeV p+ irradiation.

V_2(=/-):

Similar introduction rate like for 23 GeV p+ irradiation

V_2(-/0):

Introduction rate is only half of what was found after 23 GeV p+ irradiation

Conclusions

- New Epi materials show high [O] and high [IO_2] like in MCZ
- Depth caracteristics of [IO_2] corresponds with [O]
- IO_2 defect shows bistability
- Introduction rates of vacancy related defects are nearly the same for investigated materials