Bulk defects induced by irradiation in Si

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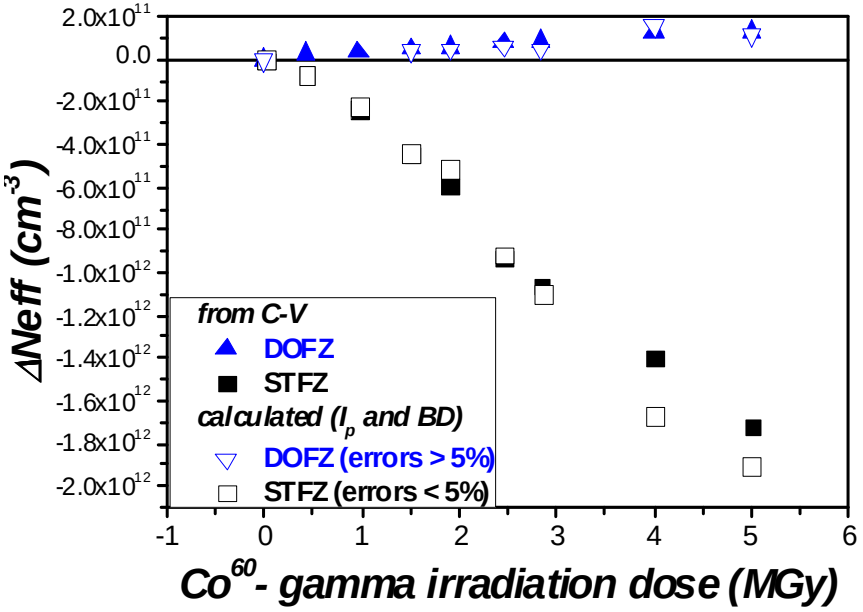
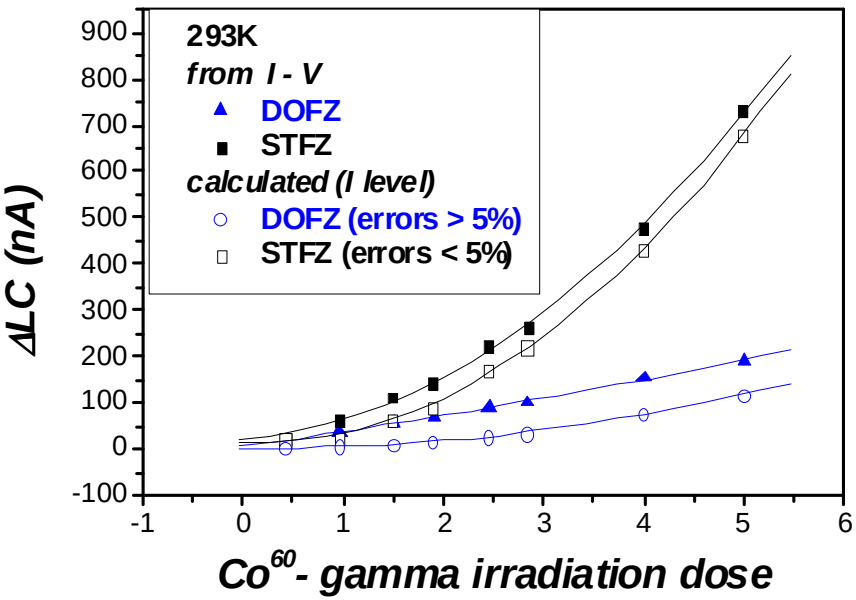
Defects induced by irradiations in Si (forming and transforming at ambient temperatures)

Defects	**$\sigma_{n,p}$ [cm^2]**	**E_A [eV]**	**Assignment/References**	**Impact on electrical characteristics at RT**
E(30K)	$\sigma_n = 2.3 \times 10^{-14}$	E_C - 0.1	Electron trap with a donor level in the upper half of the Si bandgap /[Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52]	On the N_{eff} by introducing positive space charge *-It makes the difference between proton and neutron irradiations* *-More generated in O rich material*
$BD_A^{0/++}$ $BD_B^{+/++}$	$\sigma_n = 2.3 \times 10^{-14}$ $\sigma_n = 2.7 \times 10^{-12}$	E_C - 0.225 E_C - 0.15	**Bistable Thermal double donor TDD2** (two configurations A and/or B) - Electron trap with a donor level in the upper half of the Si bandgap/ [Appl. Phys. Lett. 50 (21) (1987) 1500; Nucl. Instr. and Meth. in Phys. Res. A 514 (2003) 18; Nucl. Instr. and Meth. in Phys. Res. A 556 (2006) 197; Nucl. Instr. and Meth. in Phys. Res. A 583 (2007) 58]	On the N_{eff} by introducing positive space charge *-Strongly generated in O rich material*
$I_p^{+/0}$ $I_p^{0/-}$	$\sigma_p = (0.5\text{-}9) \times 10^{-15}$ $\sigma_n = 1.7 \times 10^{-15}$ $\sigma_p = 9 \times 10^{-14}$	E_V + 0.23 E_C - 0.55	Donor level of V_2O or of a still unkown C related defect / [Appl. Phys. Lett. 81 (2002) 165; Appl. Phys. Lett. 83, 3216 (2003); Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52] Acceptor level of V_2O or of a still unkown C related defect/[Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52, Appl. Phys. Lett. 81 (2002) 165]	On the N_{eff} by introducing negative space charge and on LC *-Strongly generated in O lean material*
E_4 E_5	$\sigma_n = 1 \times 10^{-15}$ $\sigma_n = 7.8 \times 10^{-15}$	E_C -0.38 E_C -0.46	Acceptor in the upper part of the gap associated with the double charged and single charged states of V_3, respectively (**$V_3^{=/-}$ and $V_3^{-/0}$**) / [J. Appl. Phys. 111 (2012) 023715.]	On LC
H(116K)	$\sigma_p = 4 \times 10^{-14}$	E_V + 0.33	Hole trap with an acceptor level in the lower part of the Si bandgap - Extended defect (cluster of vacancies and/or interstitials) / [Appl. Phys. Lett. 92 (2008) 024101, Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52-68]	On the N_{eff} by introducing negative space charge
H(140K)	$\sigma_p = 2.5 \times 10^{-15}$	E_V + 0.36	Hole trap with an acceptor level in the lower part of the Si bandgap - Extended defects (clusters of vacancies and/or interstitials)/[Appl. Phys. Lett. 92 (2008) 024101, Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52-68]	On the N_{eff} by introducing negative space charge
H(152K)	$\sigma_p = 2.3 \times 10^{-14}$	E_V + 0.42	Hole trap with an acceptor level in the lower part of the Si bandgap - Extended defects (clusters of vacancies and/or interstitials)/[Appl. Phys. Lett. 92 (2008) 024101, Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52-68]	On the N_{eff} by introducing negative space charge
$VO_i^{-/0}$	$\sigma_n = 1.44 \times 10^{-14}$	E_C -0.176	**$VO_i^{-/0}$** /[J. Appl.Phys.79(1996)3906 ; Mat. Sci. in Semic. Proc. 3 (2000) 227]	
$C_iC_s^{-/0}$	$\sigma_n = 1.4 \times 10^{-14}$	E_C - 0.171	**$C_iC_s^{A-/0}$** /[Phys. Rev. Lett. 60 (1988) 460-463, Phys. Rev. B42 (1990) 5765]	
H(40K)	$\sigma_p = 1.7 \times 10^{-15}$	E_V + 0.09	Hole trap/ [Nucl. Instr. and Meth. in Phys. Res. A 611 (2009) 52-68]	
$C_i^{+/0}$	$\sigma_p = 4.3 \times 10^{-15}$	E_V + 0.284	**$C_i^{+/0}$**/ [M. Moll, PhD Thesis, University of Hamburg, DESY-THESIS-1999-040, 1999]	
$C_iO_i^{+/0}$	$\sigma_p = 4.3 \times 10^{-15}$		[J.Appl.Phys.79(1996)3906]	
$V_2^{-/0}$	$\sigma_n = 2.1 \times 10^{-15}$	E_C - 0.424	**$V_2^{-/0}$** / [J.Appl.Phys.79(1996)3906; M. Moll, PhD Thesis, DESY-THESIS-1999-040, 1999]	
H(87K)	$\sigma_p = 0.3 \times 10^{-15}$	E_V + 0.193	**$V_3^{0/+}$** /[Phys. Status Solidi A 208 (2011) 568.]	

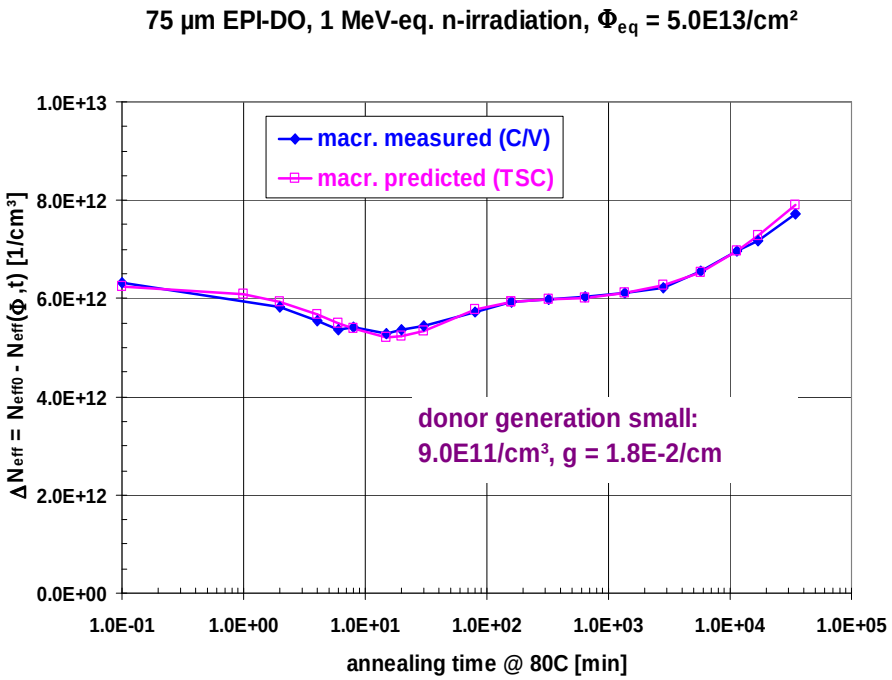
❑ Point defects – after irradiation with Co^{60} – gamma or low energy electrons

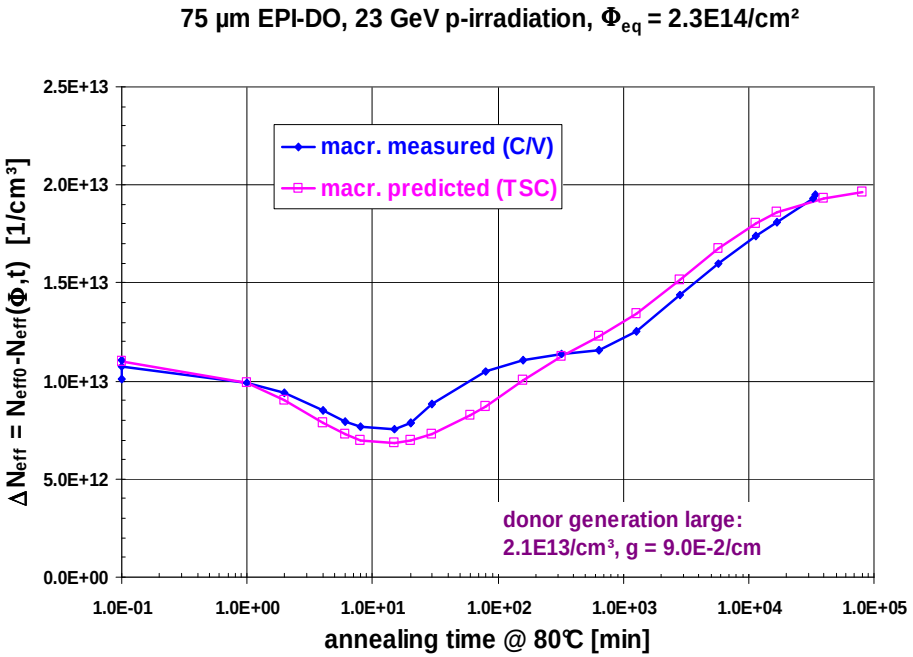




change of N_{eff} and leakage current well described by accounting only the BD (TDD2) and I_p (unknown chemical structure) defects

❑ Extended Defects – after hadron irradiation and high energy electrons





E_i^{30K} - enhanced generation after irradiation with charged hadrons

change of N_{eff} , with the irradiation fluence and annealing time, well described by accounting only the E(30K), H(116K), H(140K) and H (152K) (unknown chemical structure) defects