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Lappeenranta University of Technology

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SIMULATION OF DOUBLE JUNCTION IN IRRADIATED DETECTORS USING SILVACO TCAD

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Simulation Task

The set of parameters for cross-test simulation:

Detector thickness ---------- d=0.03 cm

Concentration of shallow donors (phosphorus) ----------N_{SD} = 6e11 cm^{-3}

Bulk generated current calculated from

2- level trap model

Type of defect	Activation energy, eV	Trapping cross section, cm^2	Introduction rate, cm^{-1}
Deep donor	E_{DD} - E_V = 0.48	$\sigma_e = \sigma_h$ = 1e-15	G_{DD} = 1
Deep acceptor	E_{DA} - E_V = 0.595	$\sigma_e = \sigma_h$ = 1e-15	G_{DA} = 1

Bulk generated current calculated from **Not available in simulation**

Single level model

Effective energy of current generating level---------- E_j – 0.65 eV

Effective cross-section of current generating level --------- s_j = 1e-13cm^2

Introduction rate of current generating level ---------- G_j = 1 cm^{-1}

Simulations are compared for:

T = 290K and 260K

V= 200V, 300V, 500V, 1000V at F = 1e15cm^{-2}

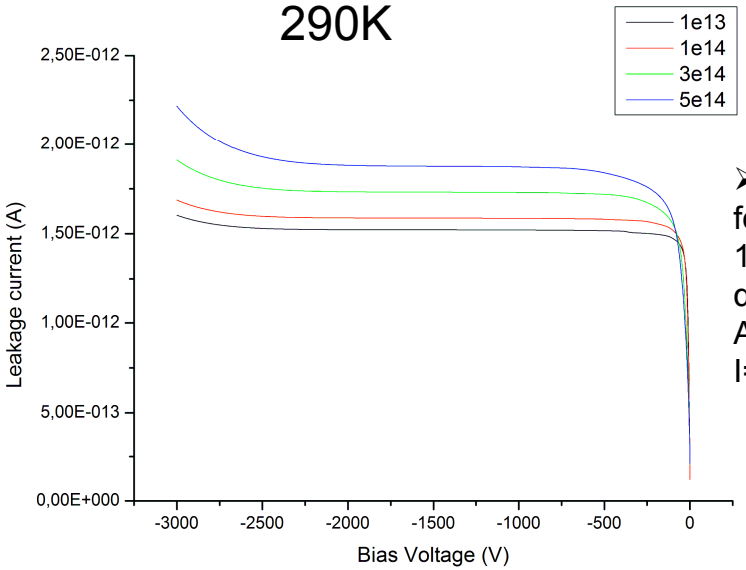
F= 1e13, 1e14, 3e14, 1e15, 3e15 cm^{-2} at V=300V

Original EVL defect model

- Simple detector 1μm × 1 μm × 300 μm
- Bulk doping [n-bulk]=6e11 cm^{-3}
- n+, p+ junction depth 1 μm
- Silvaco TCAD (5.16.3.R)

- I=α × F × Vol

290K



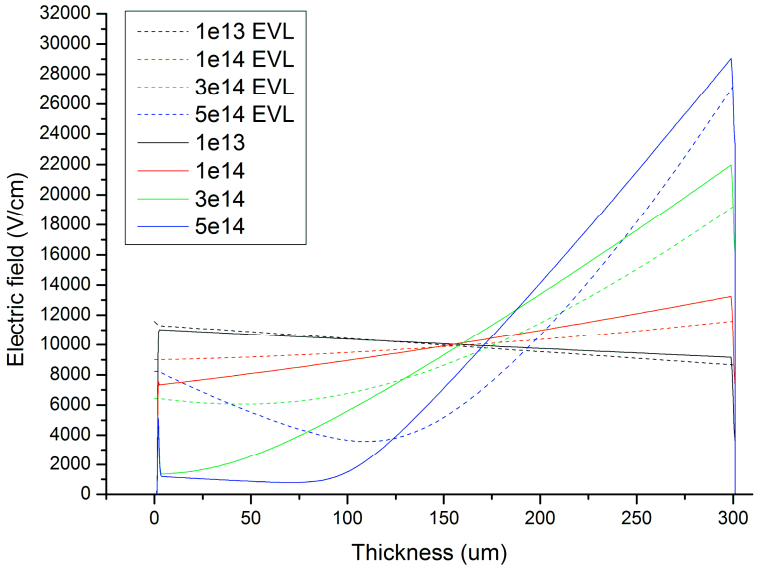
- Expected current for F=1e14 cm-2, 1x1x300um, α(290K) =4e-17 A/cm
  I=1,2e-12 A

- Does not match, decrease the current
- Tuning of the parameters

- Reascaling of the energy levels:

Silvaco Eg=1.08 eV
E.level silvaco=E.level*Egsilvaco/Eg
Eacceptor=0.504eV
Edonor=0.46eV

300V



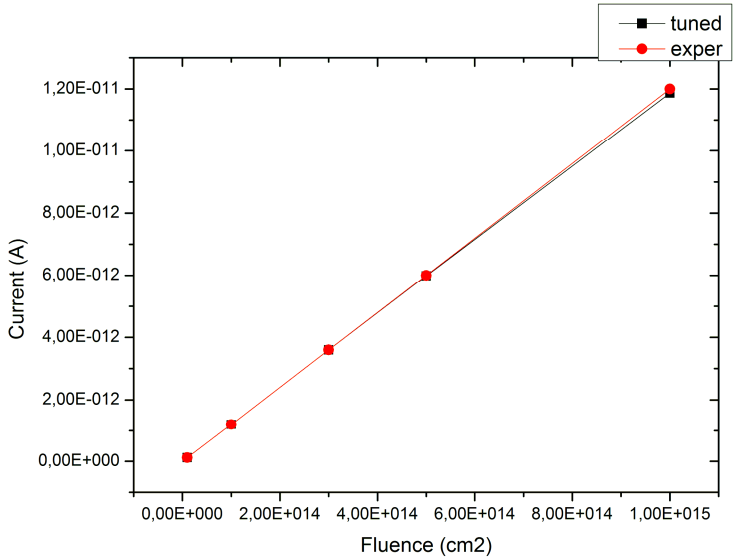
Modified EVL

- EVL

Type of defect	Activation energy, eV	Trapping cross section, cm^2	Introduction rate, cm^{-1}
Deep donor	$E_{DD} - E_V = 0.48$	$\sigma_e = \sigma_h = 1e\text{-}15$	$G_{DD} = 1$
Deep acceptor	$E_{DA} - E_V = 0.595$	$\sigma_e = \sigma_h = 1e\text{-}15$	$G_{DA} = 1$

- Modified

Type of defect	Activation energy, eV	Trapping cross section, cm^2	Introduction rate, cm^{-1}
Deep donor	$E_{DD} - E_V = 0.48$	$\sigma_e = 4e{-}14$ $\sigma_h = 1e\text{-}14$	$G_{DD} = 1.63$
Deep acceptor	$E_{DA} - E_V = 0.59$	$\sigma_e = 4e{-}14$ $\sigma_h = 1e\text{-}14$	$G_{DA} = 1.63$



290K

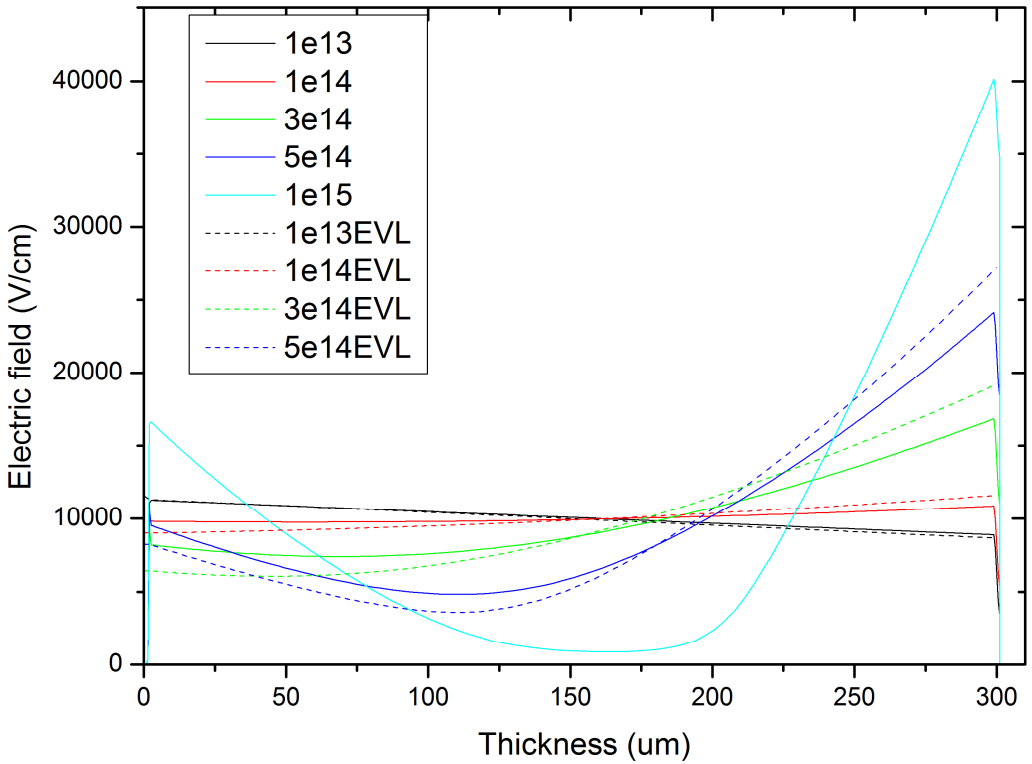
- Good agreement of experimental value of current and modified simulation

Modified EVL, 290K

Simulations at 290K

Trap introduction rate=1.63
Acceptor(σn =4e-14 cm2, σp=1e-14 cm2),
Donor (σn =4e-14 cm2, σp =1e-14 cm2)
τ0 = 1e-3 sec

300V



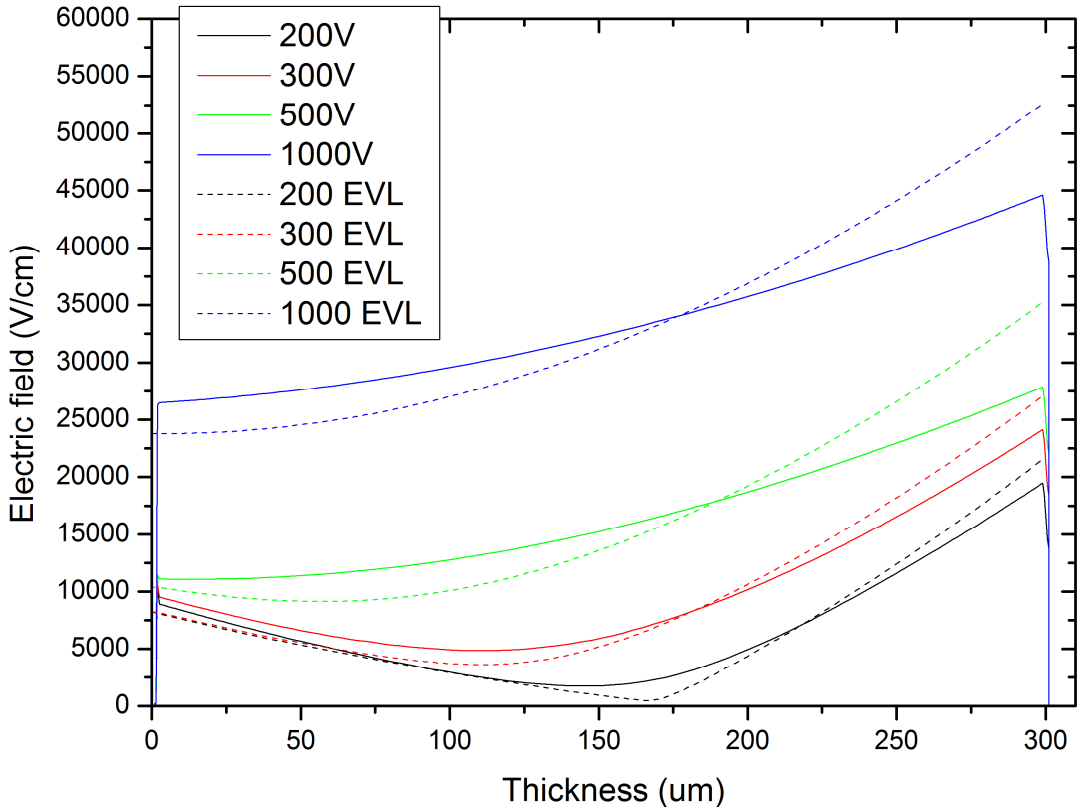
- Activation energies as in EVL model
- Good agreement

Modified EVL, 290K

Simulations at 290K
Trap introduction rate=1.63
Acceptor(σn =4e-14 cm2, σp=1e-14 cm2),
Donor (σn =4e-14 cm2, σp =1e-14 cm2)
τ0 = 1e-3 sec

➢Activation energies as in EVL model

F=5e14 cm-2

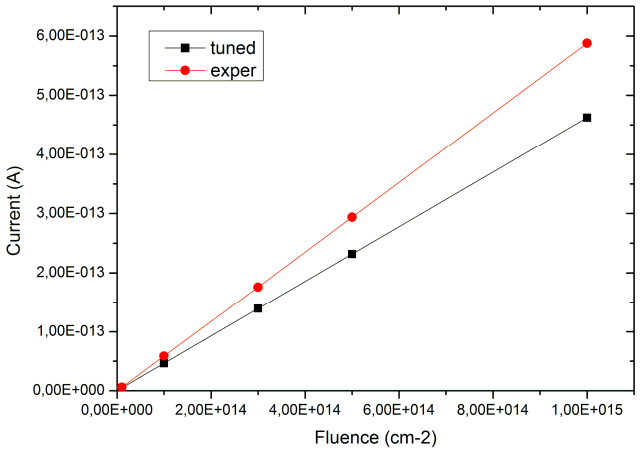


Modified EVL, 260K

Simulations at 260K

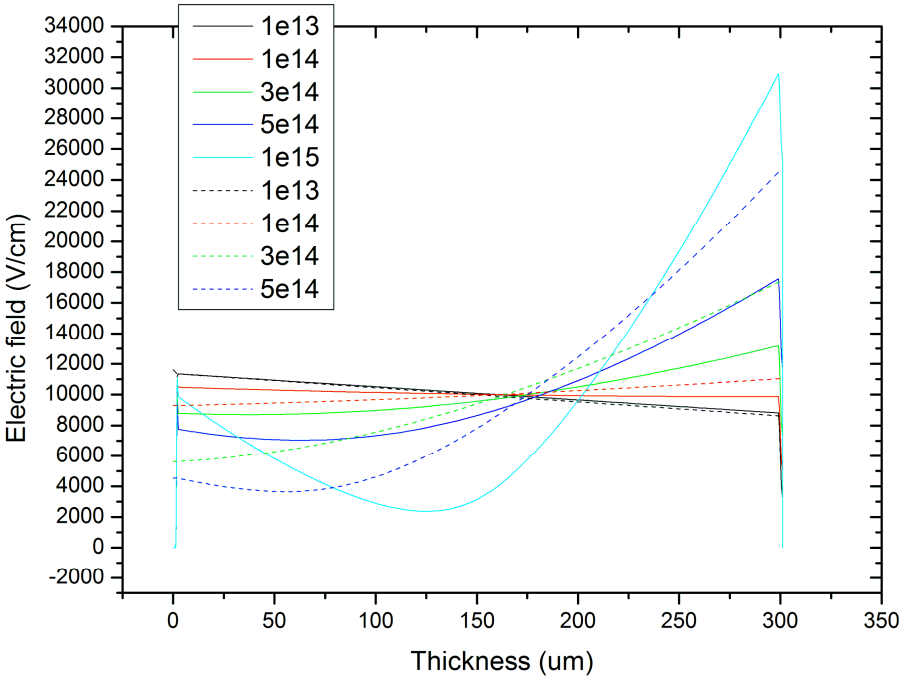
Trap introduction rate=1.63
Acceptor(σn =4e-14, σp=1e-14),
Donor (σn =4e-14, σp =1e-14)]
τ0 = 1e-3 sec

➢Activation energies as in EVL model



α(260K) =1.96e-18 A/cm

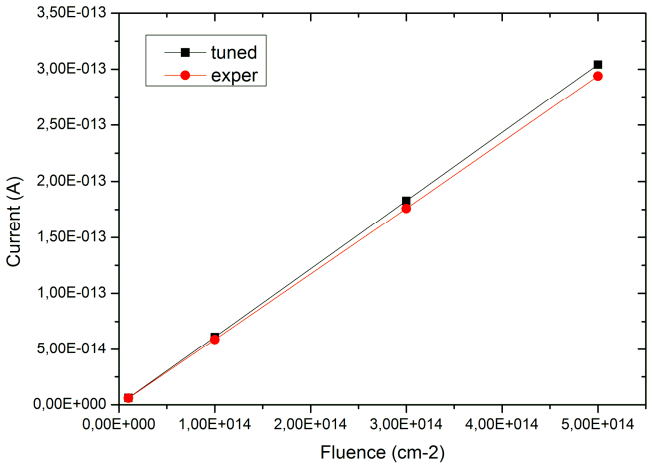
300V

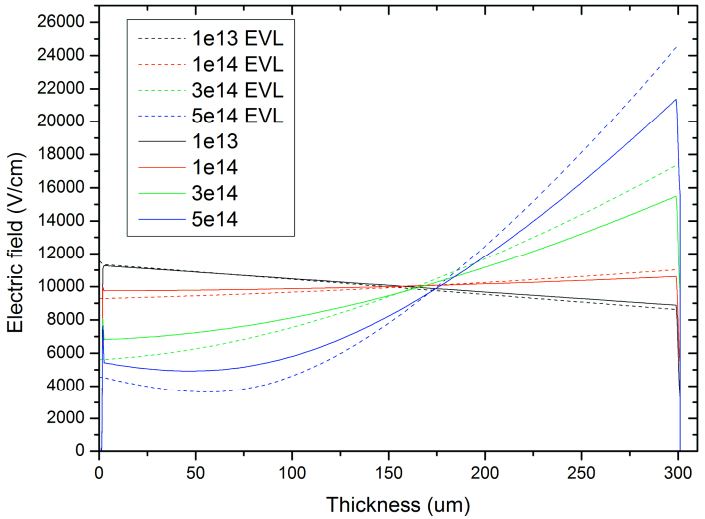


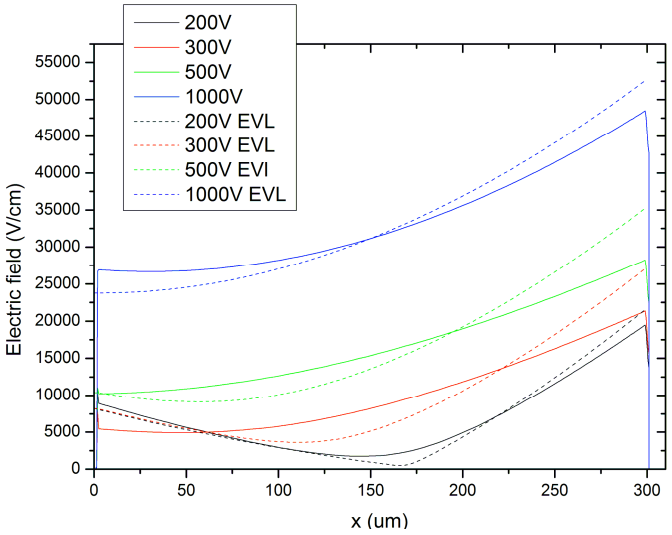
➢Less number of traps are activated

Modified EVL, 260K

Simulations at 260K
Trap introduction rate=1.43
Acceptor(σn =3e-14, σp=1.5e-14),
Donor (σn =3e-14, σp =1.5e-14)
τ0 = 1e-3 sec





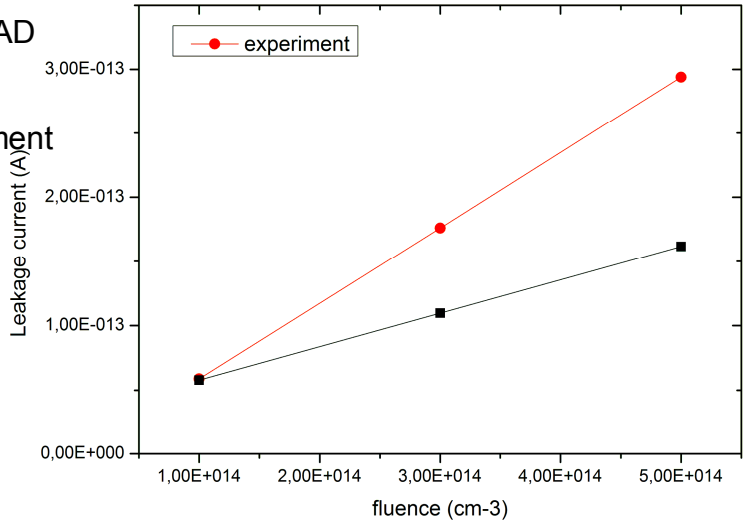


EVL defect model, tuned by Robert Eber, KIT

253K

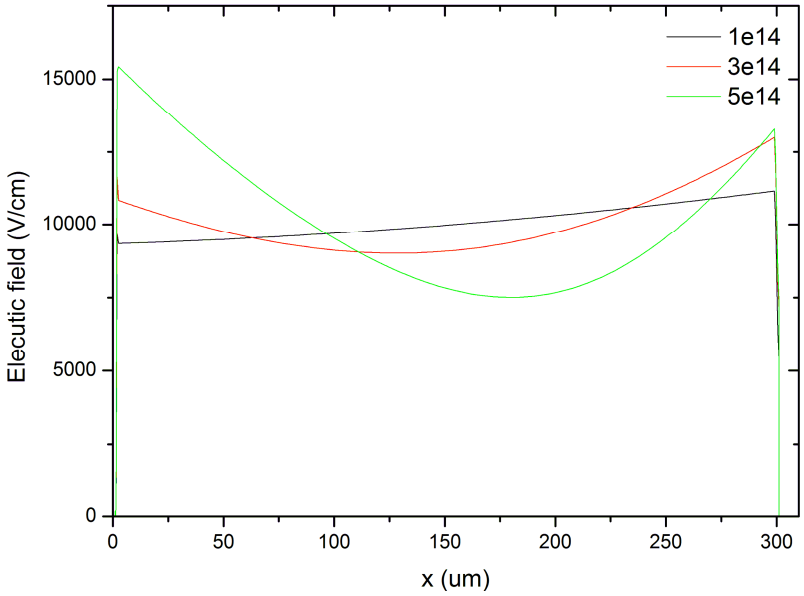
Type of defect	Activation energy,eV	Trapping cross section,cm2	Introduction rate,cm-1	Acceptor/donor conc.,cm-3
Deep acceptor	Ec-EDA=0.525	se=sh=1e-14	GDA=1.189	1.189*F+6.454e13
Deep donor	Ev+EDD=0.48	se=sh=1e-14	GDD=5.598	5.598*F-3.959e14

- Silvaco TCAD
- No agreement in current



- α(253K) =8.8e-19 A/cm
- No inversion

253K, 300V



Summary

- Tuning of the defect parameters is a good way to modify EVL-model
- For T=290K good agreement achieved by increasing of the introduction rate to 1.63 1/cm, decreasing the ratio of the hole and electron cross section to 0.25.
- It seems that Robert Eber's model doesn't work in Silvaco as good as in Synopsys