Note on C-DLTS application for study of radiation damage produced by short range particles

by

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Motivation

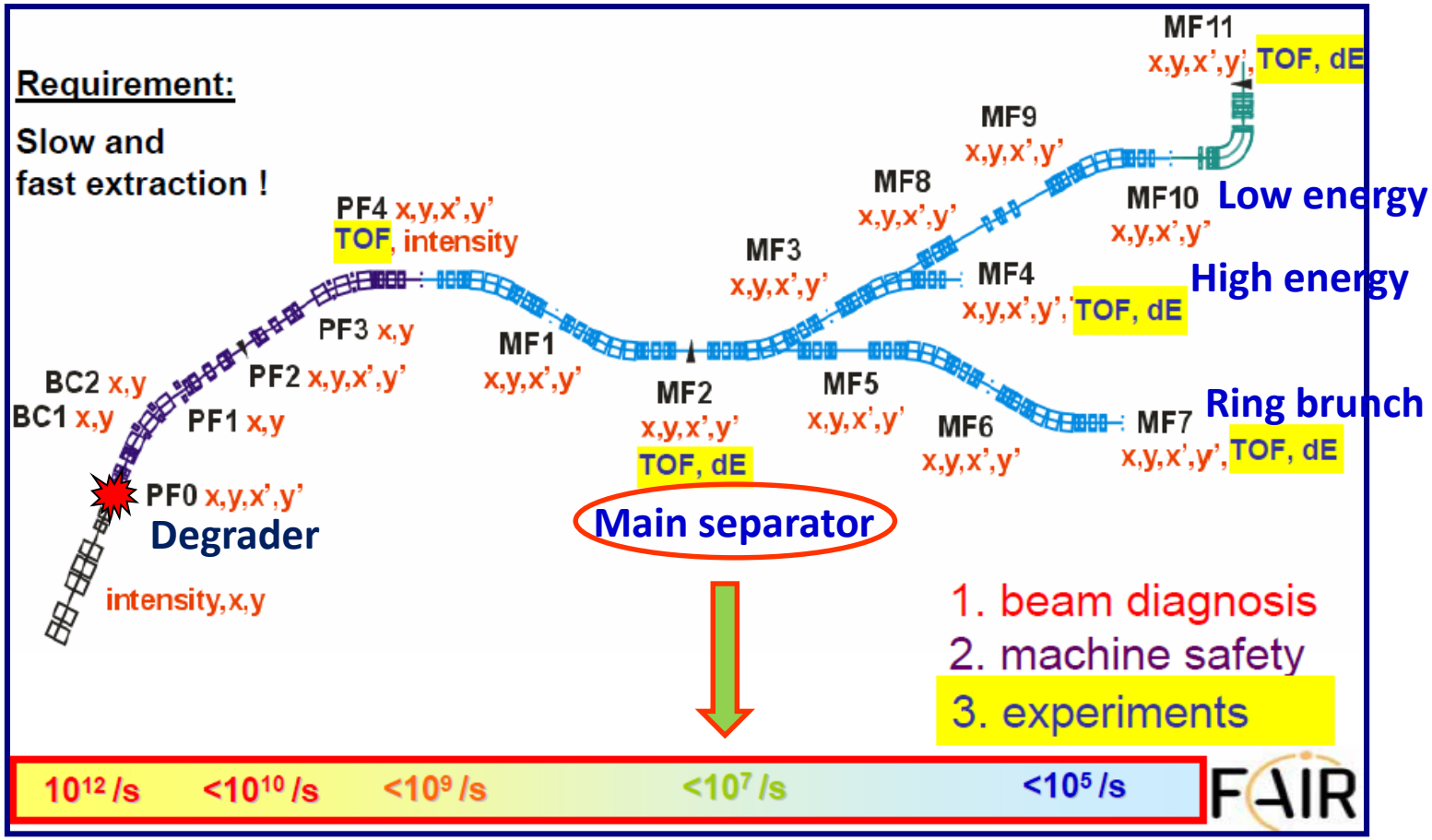
- **Growing interest for High-Luminosity accelerating facilities for heavy-ion physics investigations**

- **Unification and simplification of DLTS technique for the study of detector degradation**

- **Reduction of irradiation costs by using high energy heavy ions in the study of detector degradation.**

Beam monitoring of Super-FRS

Super Fragment Separator, GSI, Darmstadt, FAIR program



4e13 cm-2 per year

4e11 cm-2 per year

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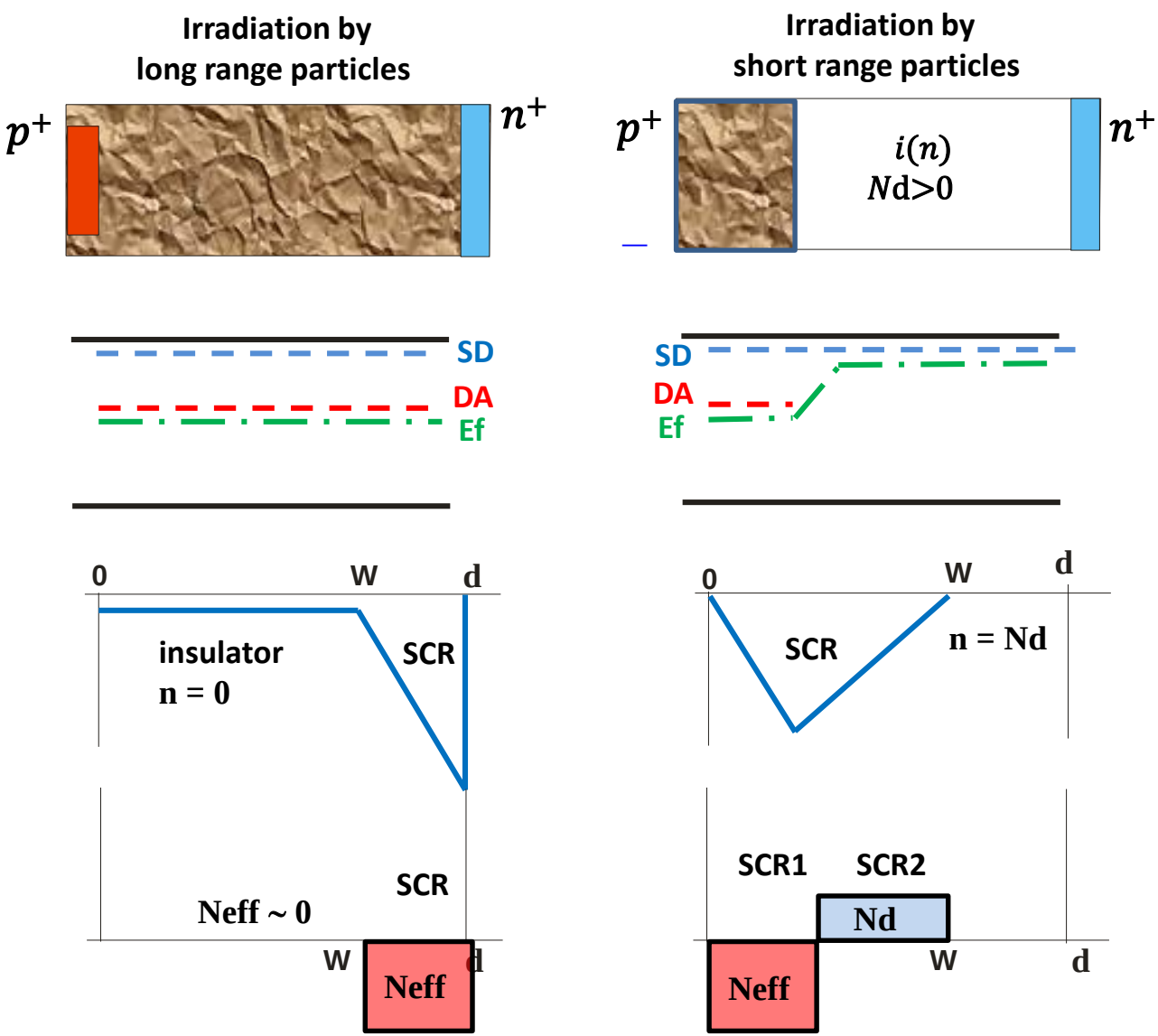
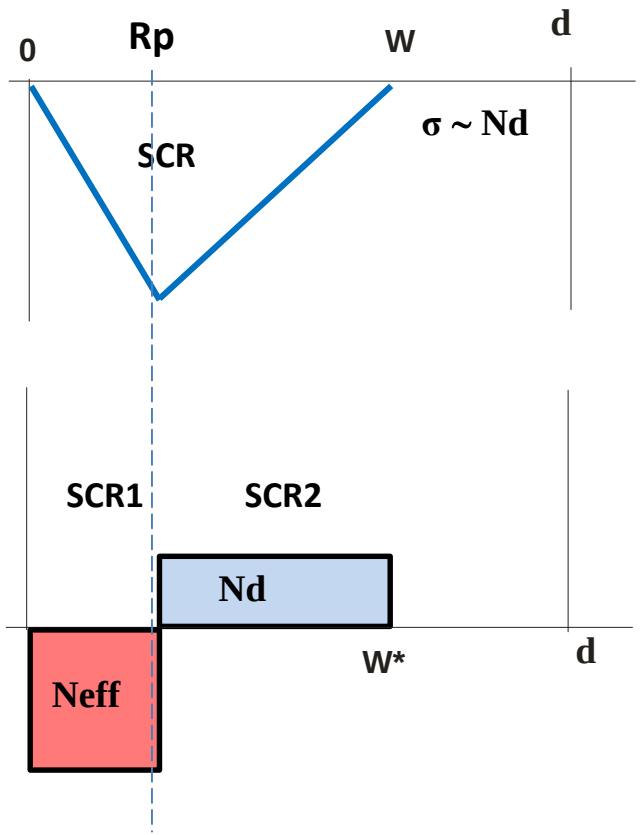
Model


Irradiation by
long range particles
p^+
n^+
SD
DA
Ef
0
W
d
insulator
n = 0
SCR
SCR
Neff ~ 0
W
d
Neff
Irradiation by
short range particles
p^+
n^+
$i(n)$
$Nd>0$
SD
DA
Ef
0
W
d
SCR
n = Nd
SCR1
SCR2
Nd
Neff
W
d

Major equations



$$W^* = \sqrt{W^2 + R_p^2\left(1 - \frac{N_{eff}}{N_d}\right)}$$

$$\frac{\Delta C}{C^*} = \left[\frac{1}{2N_d} \times \frac{R_p}{W^*}\right] \Delta N_{DL}$$

Sensitivity of C-DLTS increases with increase of the resistivity of non irradiated region

Samples for irradiation

Samples:

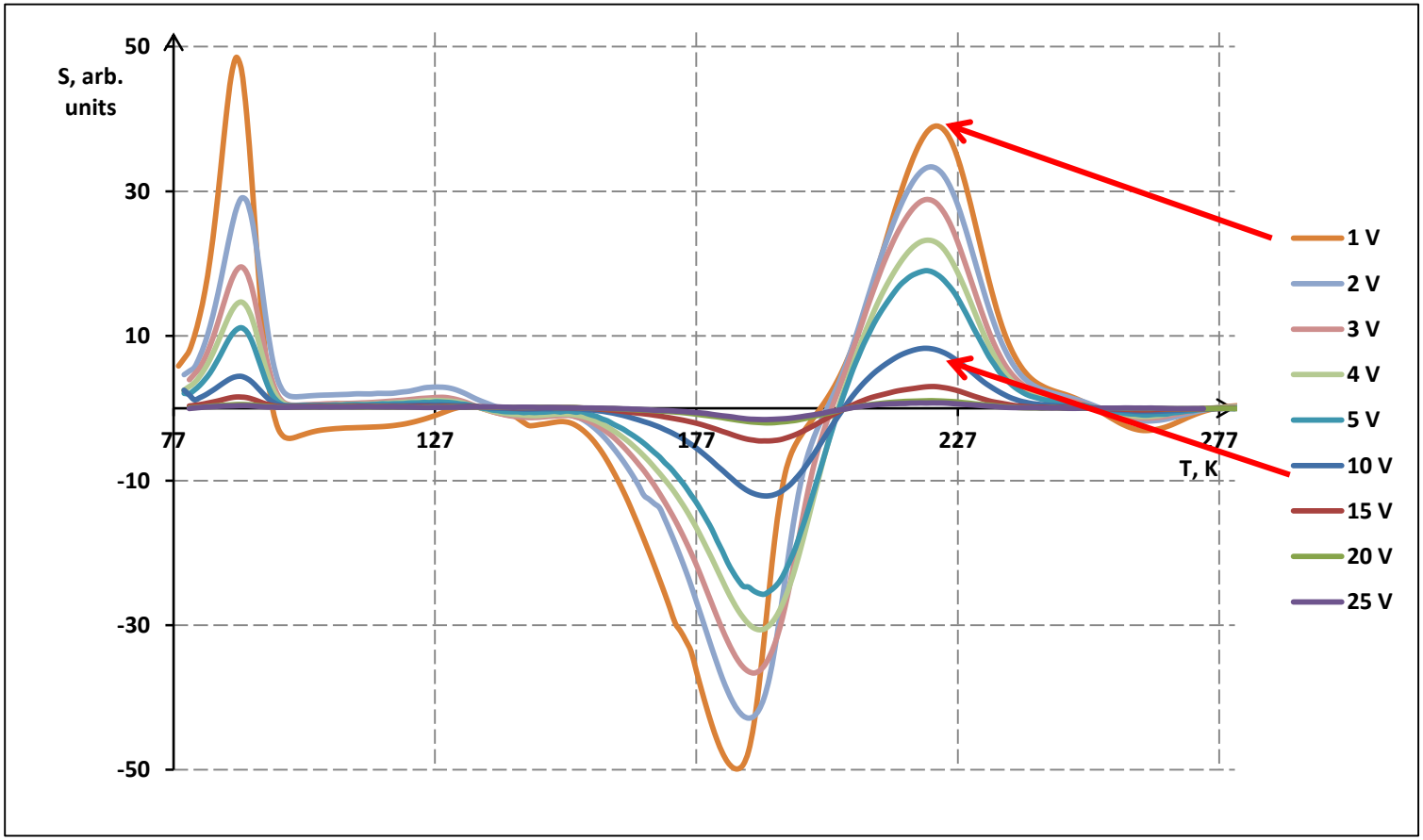
Si P-i-N structures
Epi-layers thickness = 70 um
Resistivity = 1 kOhm cm
Area = 5x5 mm2
Vfd = 12 V

Irradiation:

^{40}Ar
E = 57MeV
Rp = 14 um
F1 = 3e8 cm-3
F2 = 1e10 cm-3

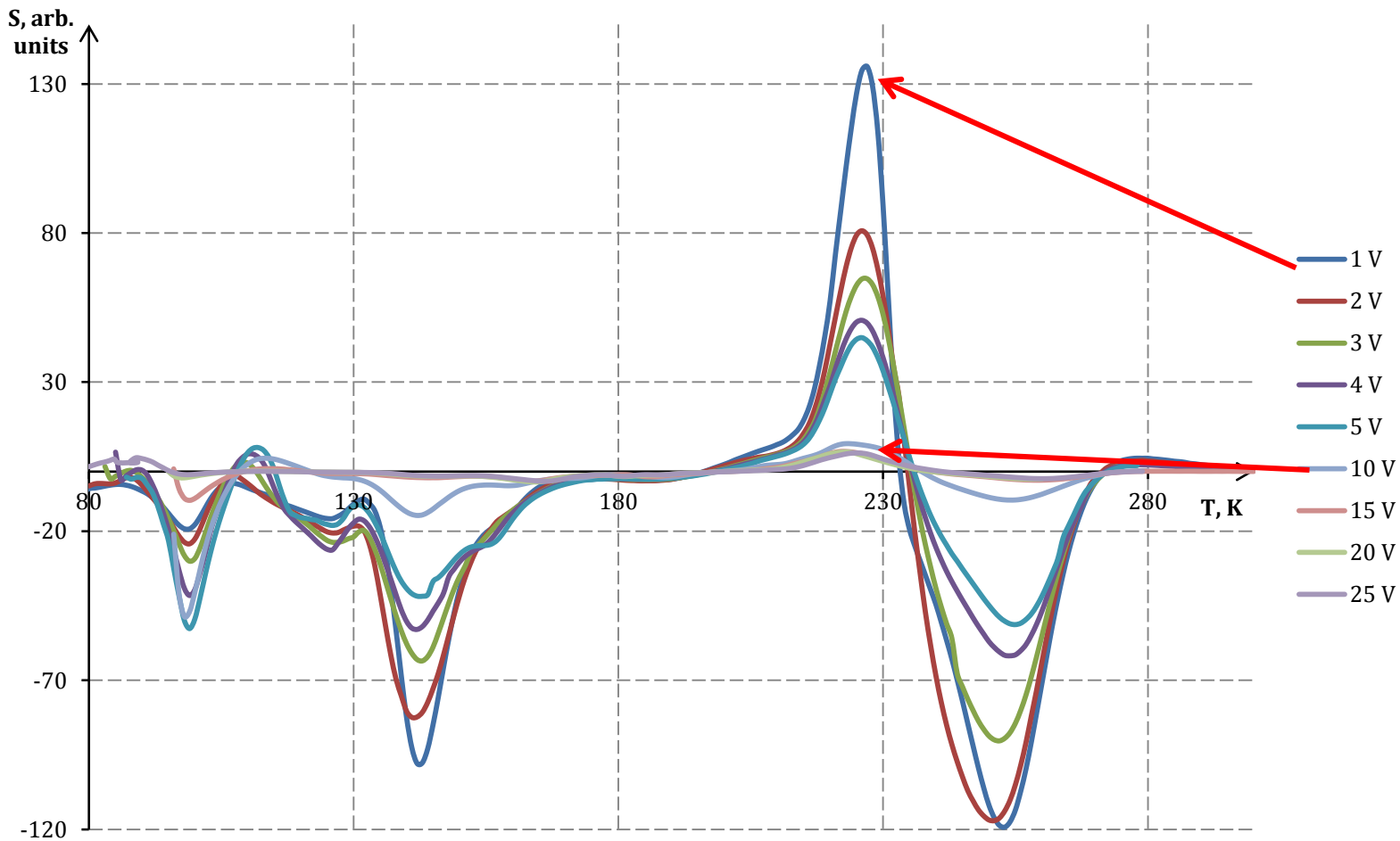
C-DLTS spectra measured at different reverse voltage

filling current – 50 mA, F = $3 \cdot 10^8$ cm^{-2}



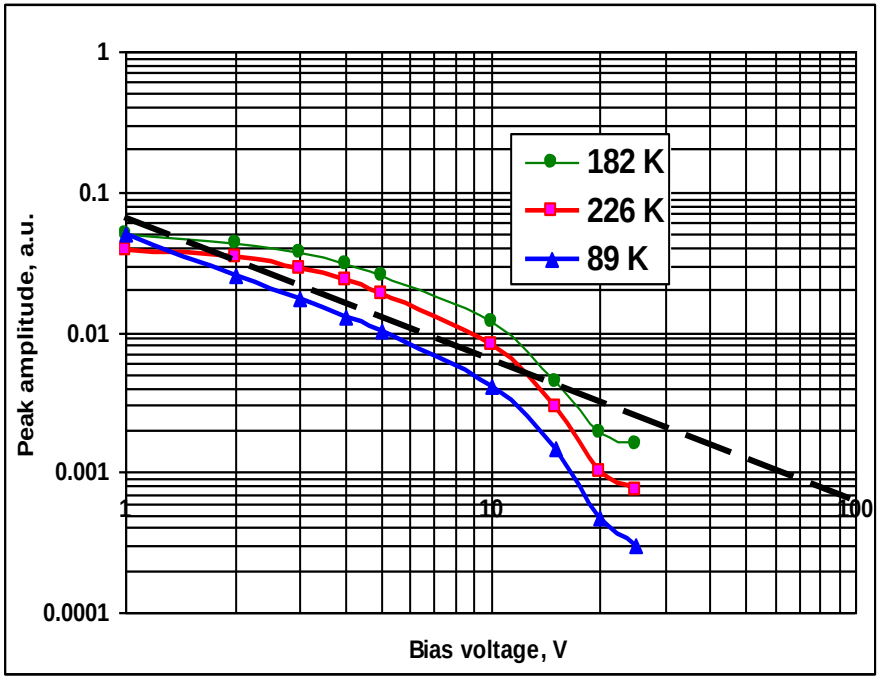
DLTS spectra measured at different reverse voltages

filling current – 50 mA, F = $1 \cdot 10^{10}$ cm^{-2}

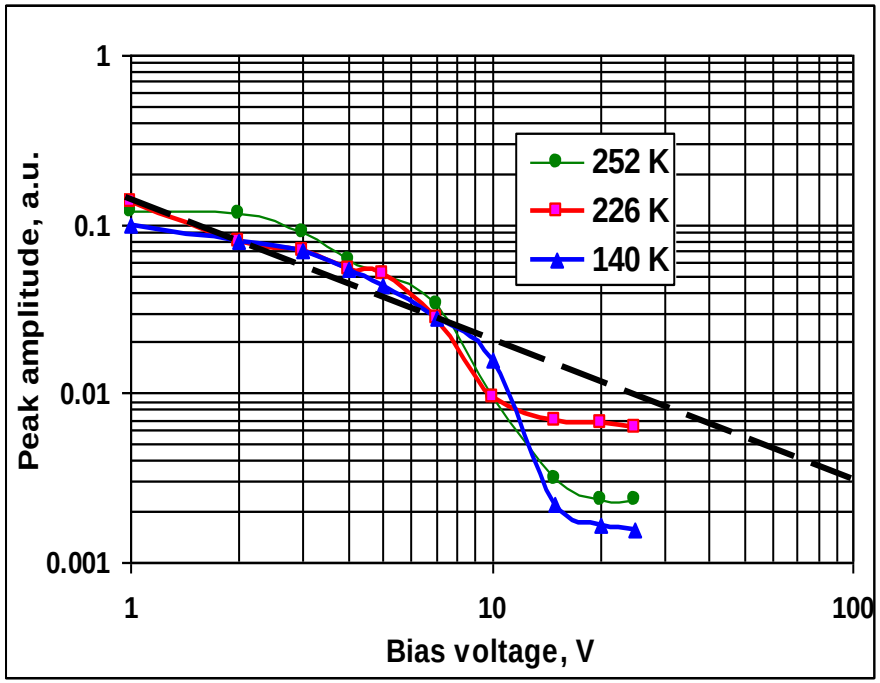


Proof of the approach

F = 3e8 cm-2



F = 1e10 cm-2



Trend line: $Y = X^{-0.5}$

Conclusions

- **Standard C-DLTS allows measurement of DL spectra in overcompensated silicon diodes.**
- **The C-DLTS sensitivity depends on the resistivity of nondepleted part of the device structure and rises as the resistivity increases.**
- **The technique eliminates limitation for the C-DLTS application for overcompensated materials in diodes.**