Electrical characterization and polarization effect of the ultra fast heteroepitaxial diamond detectors

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Contributing...

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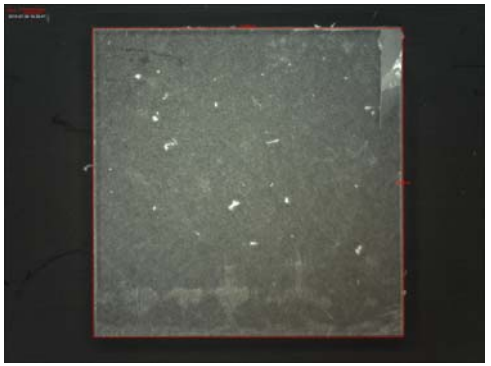
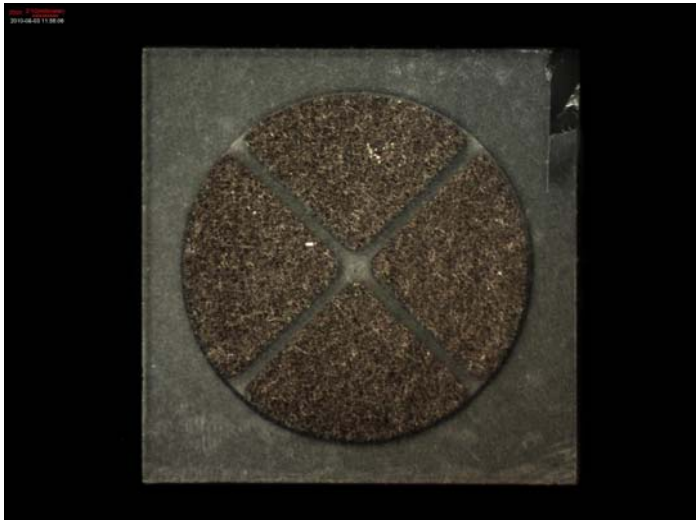
Outlines

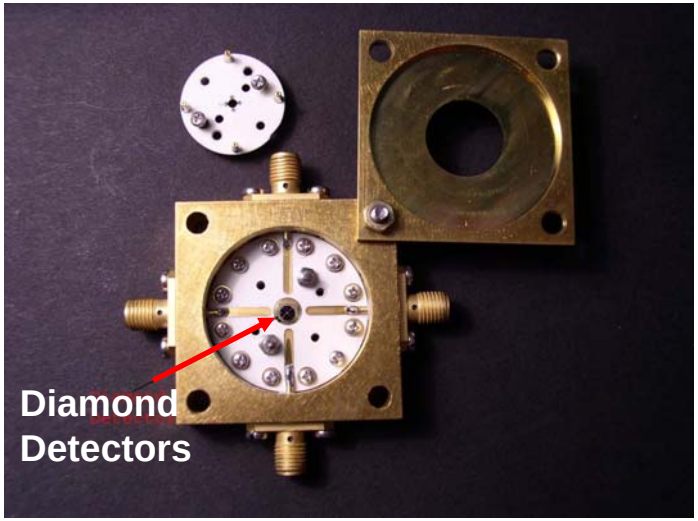
- Introduction
- Electrical and Electronic Properties
- Polarization and Memory Effects
- Conclusions

Diamond Detectors

Diamond

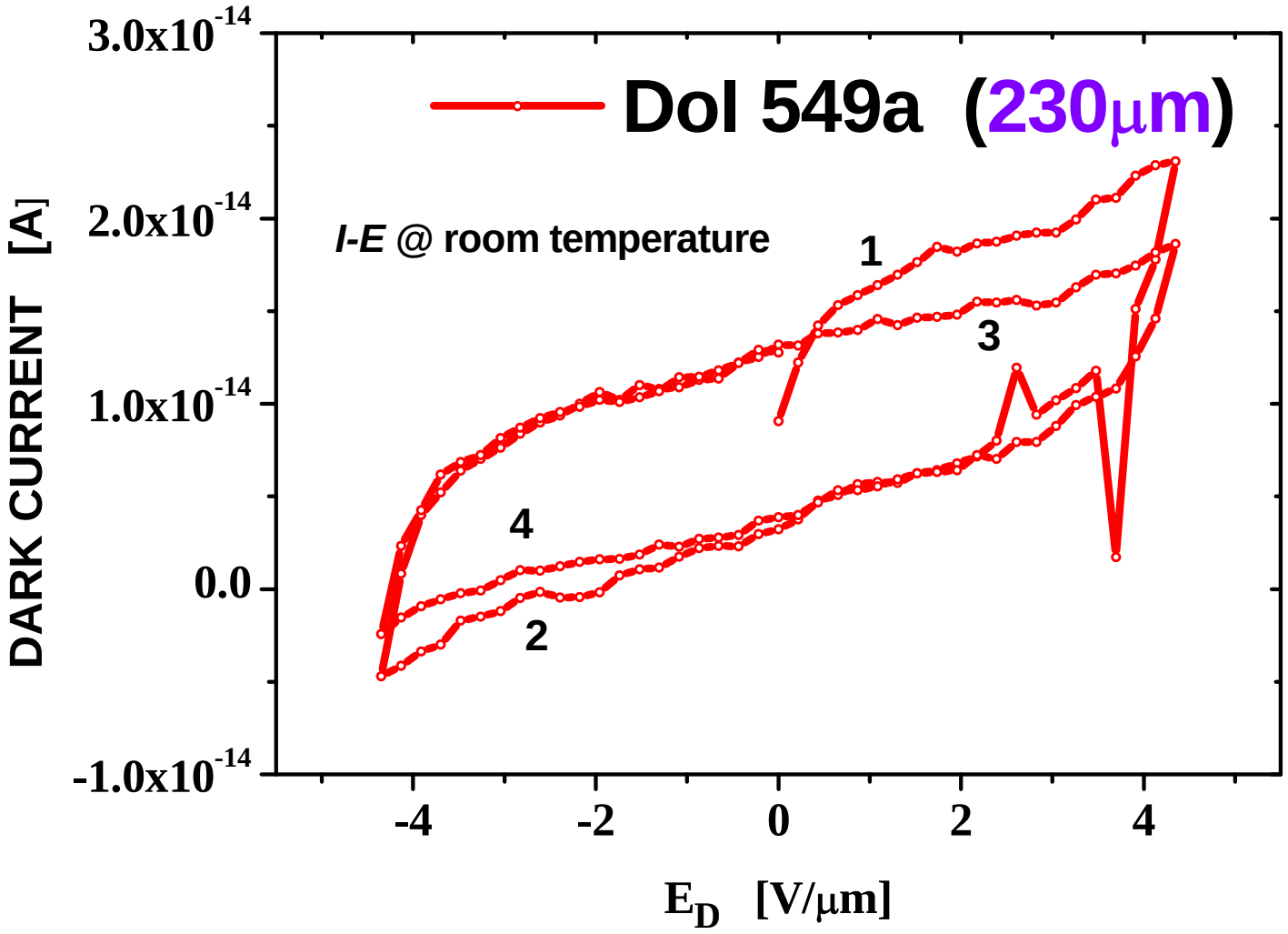




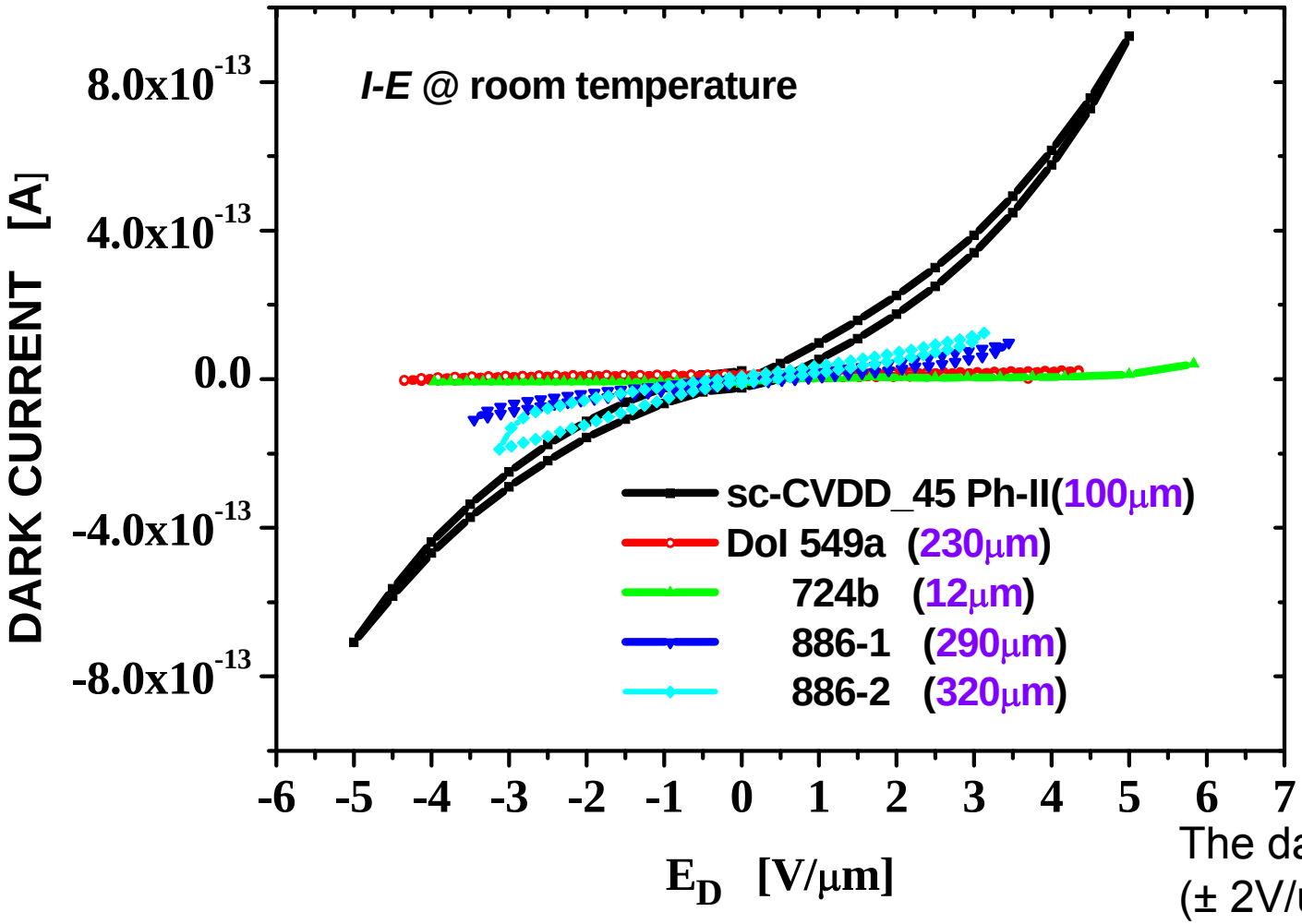


Diamond Detectors

I-E characteristics DoI Detectors



I-E characteristics CVDD Detectors



The dark current density (± 2V/um) of DoI is 1order of magnitude smaller than sc-CVDD detectors

Electrical Conductivity

Electrode-Limited conduction

- **Schottky (Thermionic) emission**

$$\ln(J/T^2) \propto E_D^{1/2}$$

- **Tunneling Current**
  - **Direct Tunneling (DT)**
  - **Fowler Nordheim (FN)**

$$\ln(J/E^2) \propto E^{1/2}$$

Bulk-Limited conduction

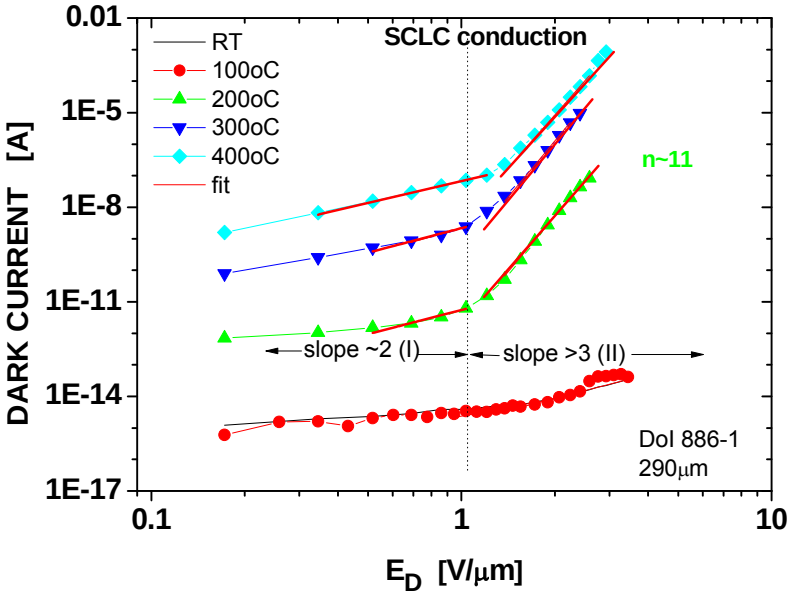
- **SCLC** $I \propto V^2$
- **Poole-Frenkel (P-F) conduction**

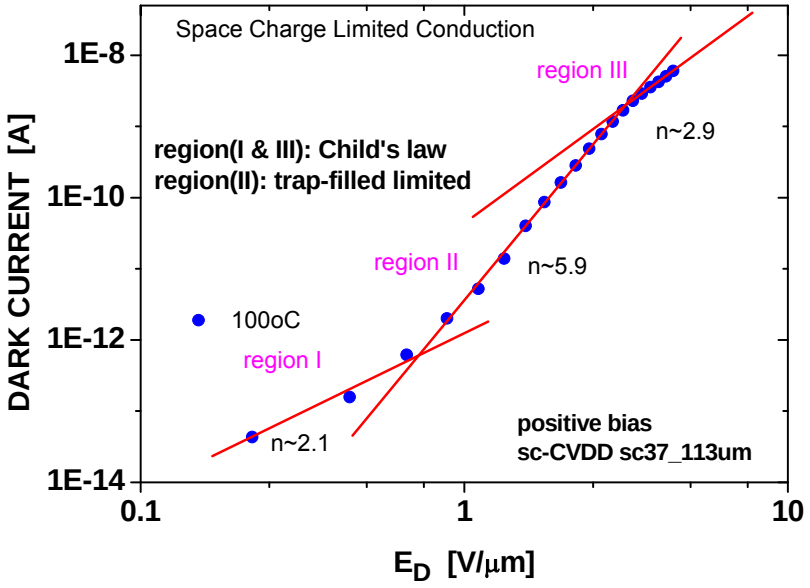
$$\ln(J/E_D) \propto E_D^{1/2}$$

- **Trap Assisted Tunneling (TAT)**

$$\ln(J) \propto E^{1/2}$$

Conduction Mechanism (SCLC)





type: sc CVD-DD, DoI DD
contact: Al, Ti/Pt/Au, Al/DLC-Dia

theory of SCLC

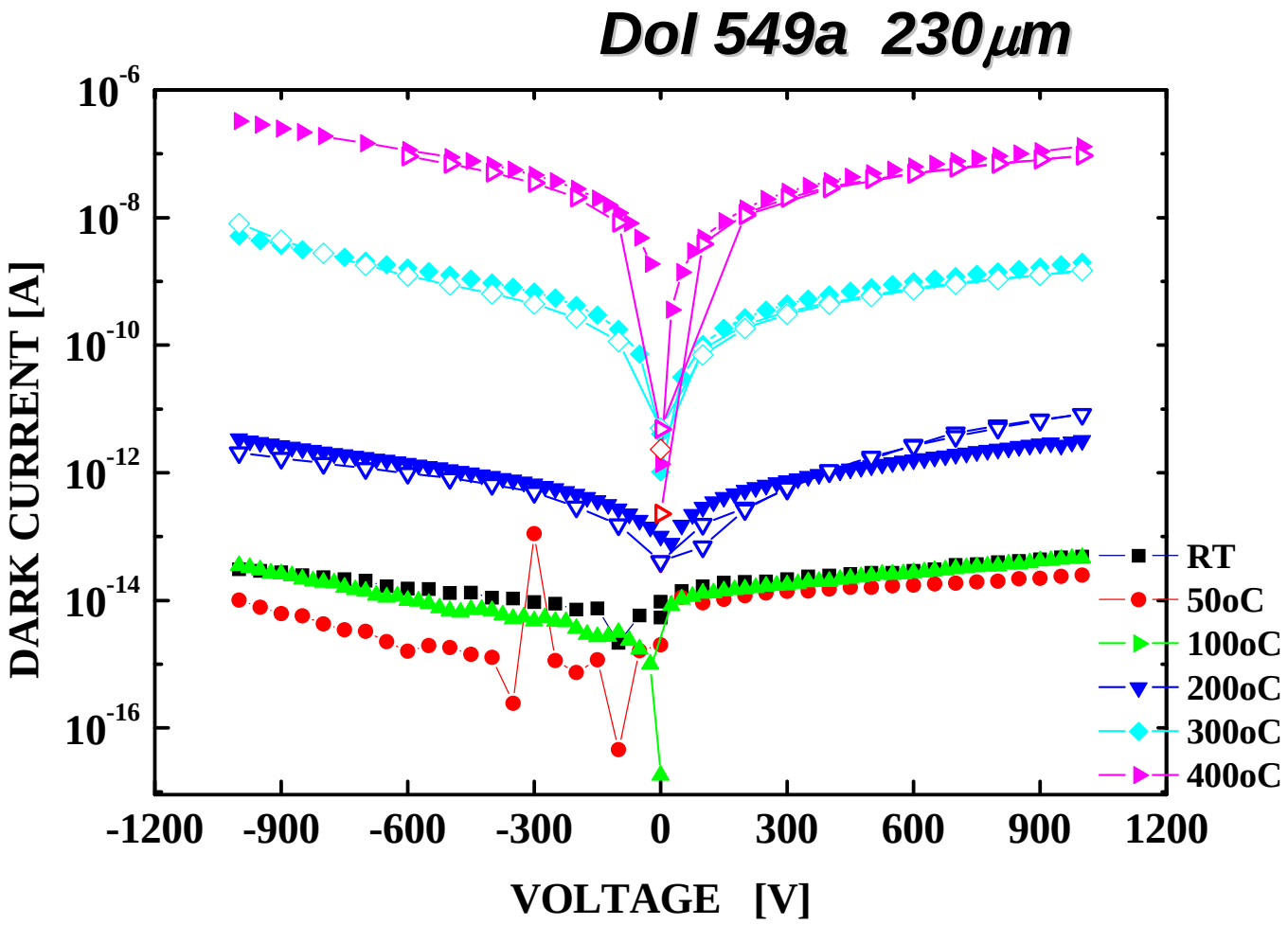
$$I_{Child} = \frac{9}{8}\mu\varepsilon\frac{V^2}{d^3}$$

$$I_{TFL} = \frac{9}{8}\mu\varepsilon\theta\frac{V^2}{d^3}$$

Here,
μ electronic mobility, V applied bias
d thickness, ε dielectric constant

$$\theta = \frac{free\_Carrier\_Density}{Total\_Carrier\_Density}$$

Effect of metalization on DoI



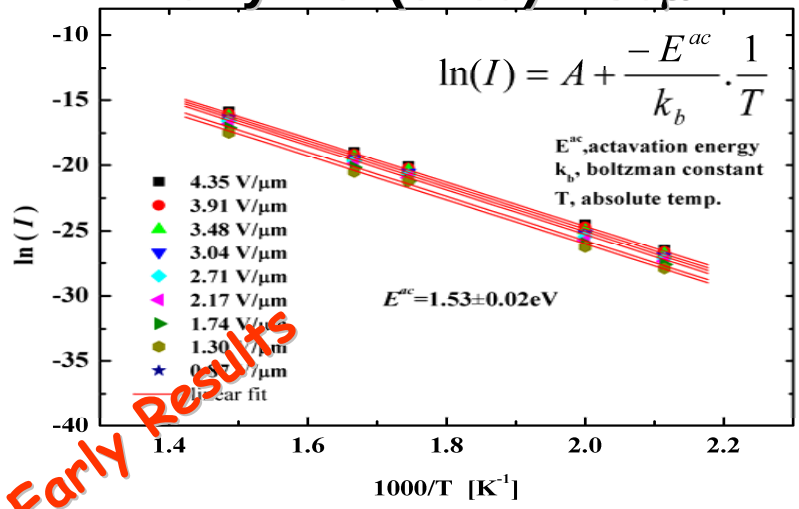
Solid and open symbols correspond to metallization with Ti/Pt/Au & Al respectively

Different metallization doesn't change effectively the dark current

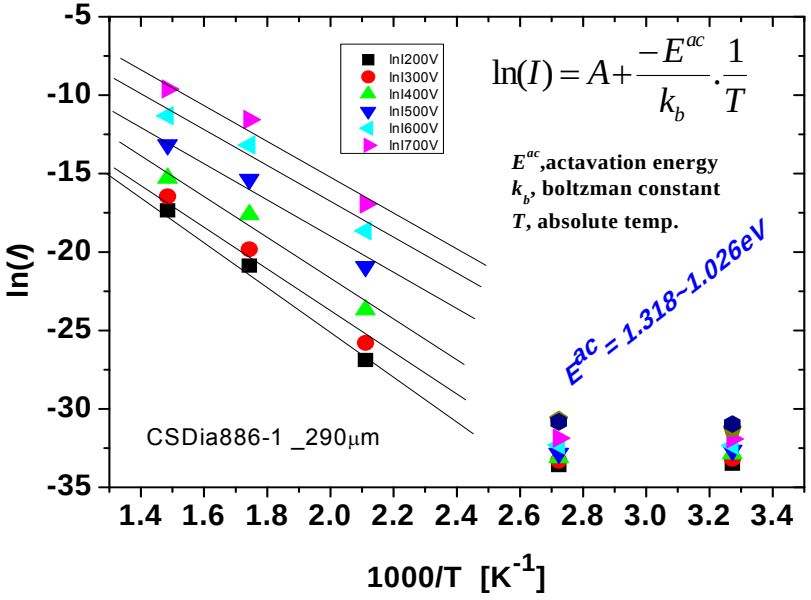
I-V characteristics at higher temp (>RT)

E^{ac} of DoI & sc-CVDD

Early DoI (549a) 230µm

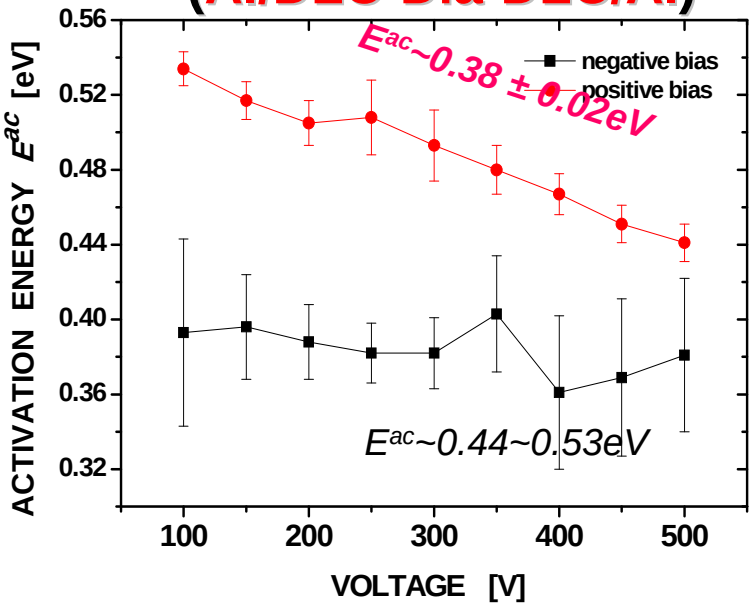


Early Results



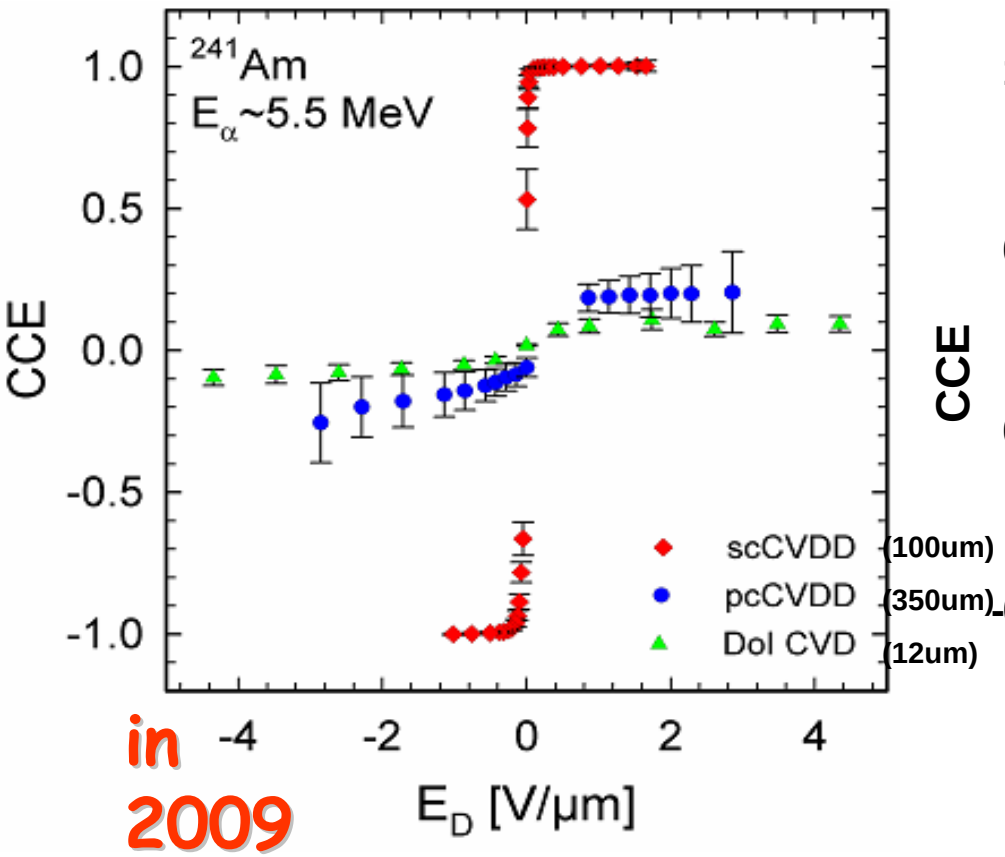
Ti/Pt/Au & Al

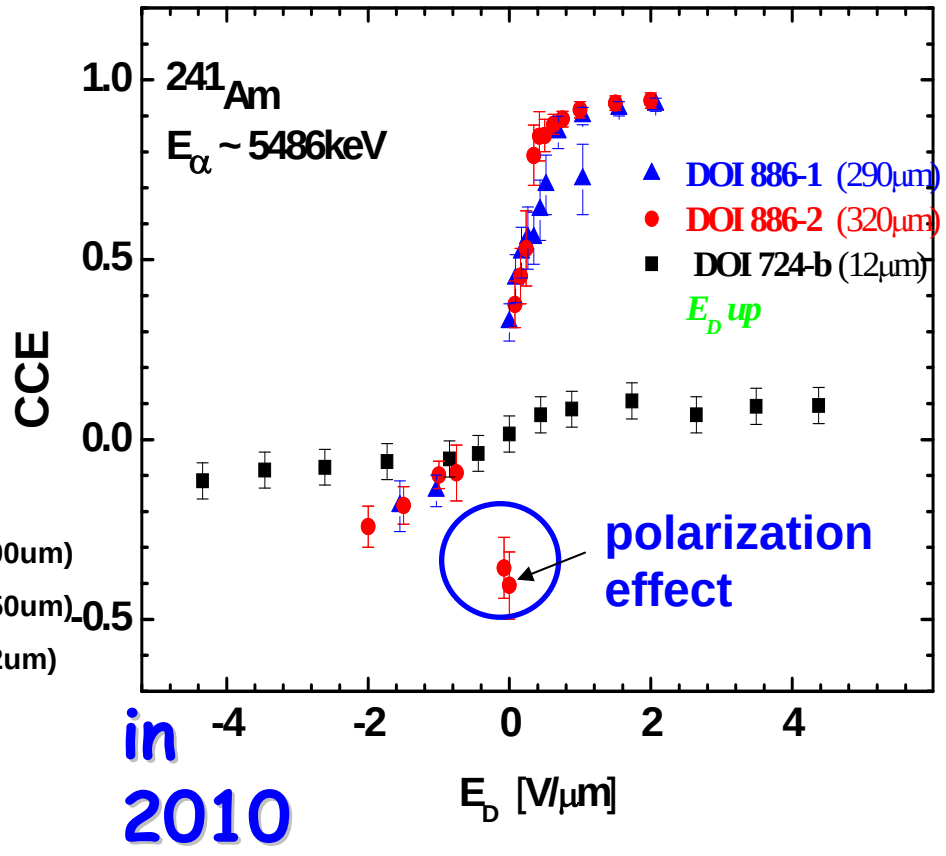
scCVDD sc37 _ 113mm (Al/DLC-Dia-DLC/Al)



Ref.: E^{ac}=1.4eV (DoI); A. Stolz, et al.,DRM 2006
E^{ac}=0.37~0.39eV (scCVDD); M. Pomorski ,Thesis

Charge Collection Efficiency (CCE) of CVDD



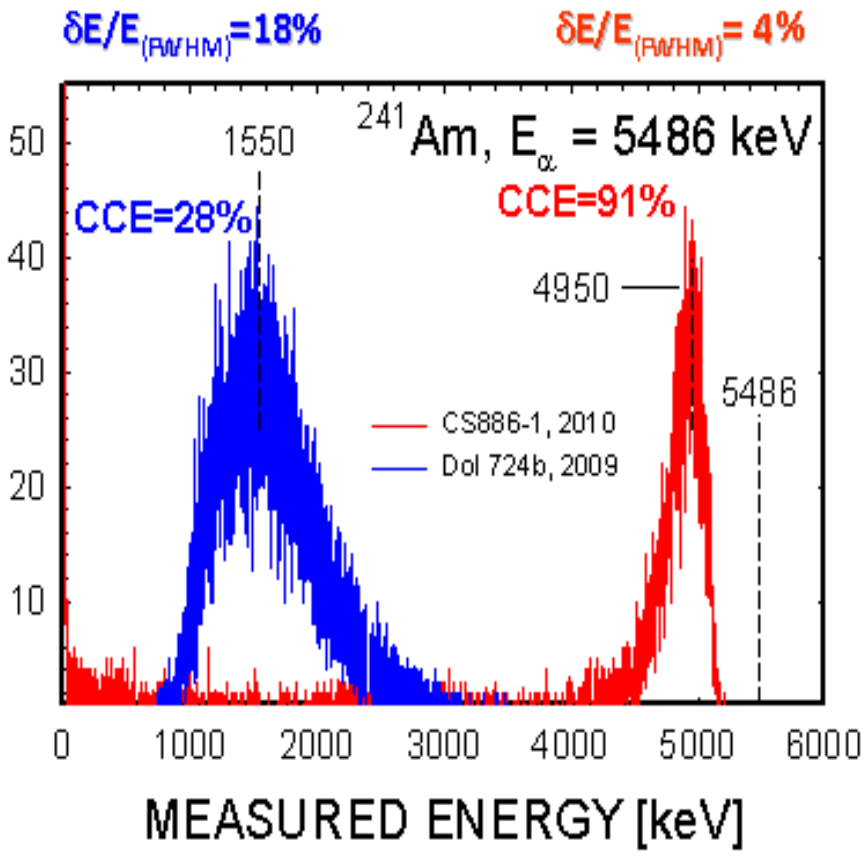


CCE of 3 different CVDDs

CCE of different DoI Detectors

The improvement of the CCE in DoI could be due the of the materials quality

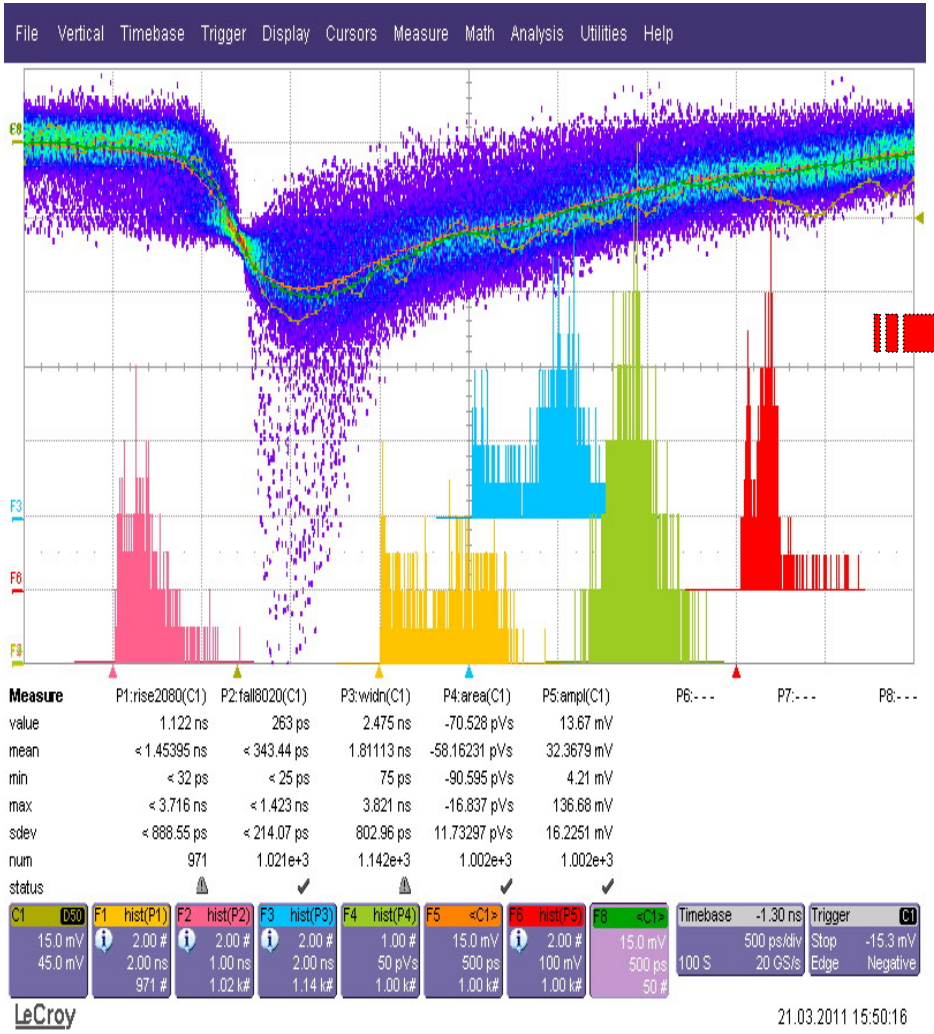
CCE and energy resolution of DoI



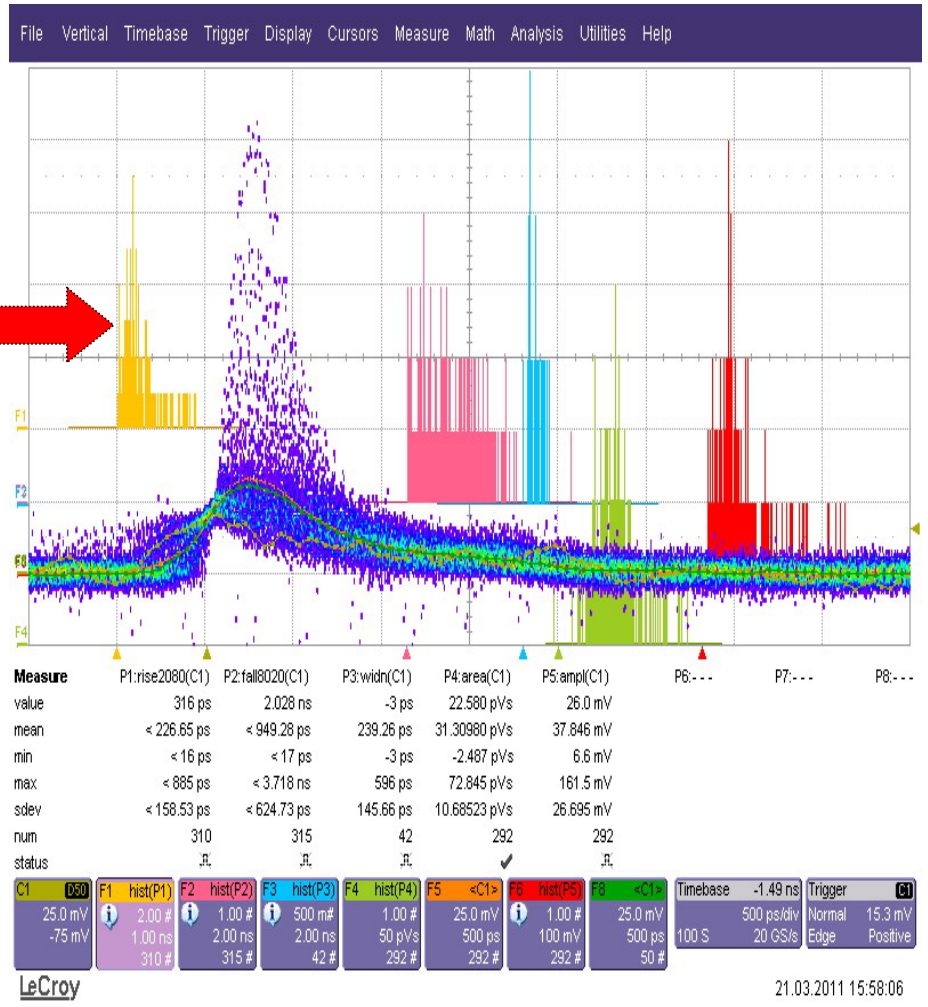
Early DoI	Recent DoI
CCE =(11~28)%	→ (91~94) %
dE/E = 18%	→ 4%

Dramatic improvement of the DoI detector in terms of CCE, energy and time resolution

Polarization effect in DoI detectors

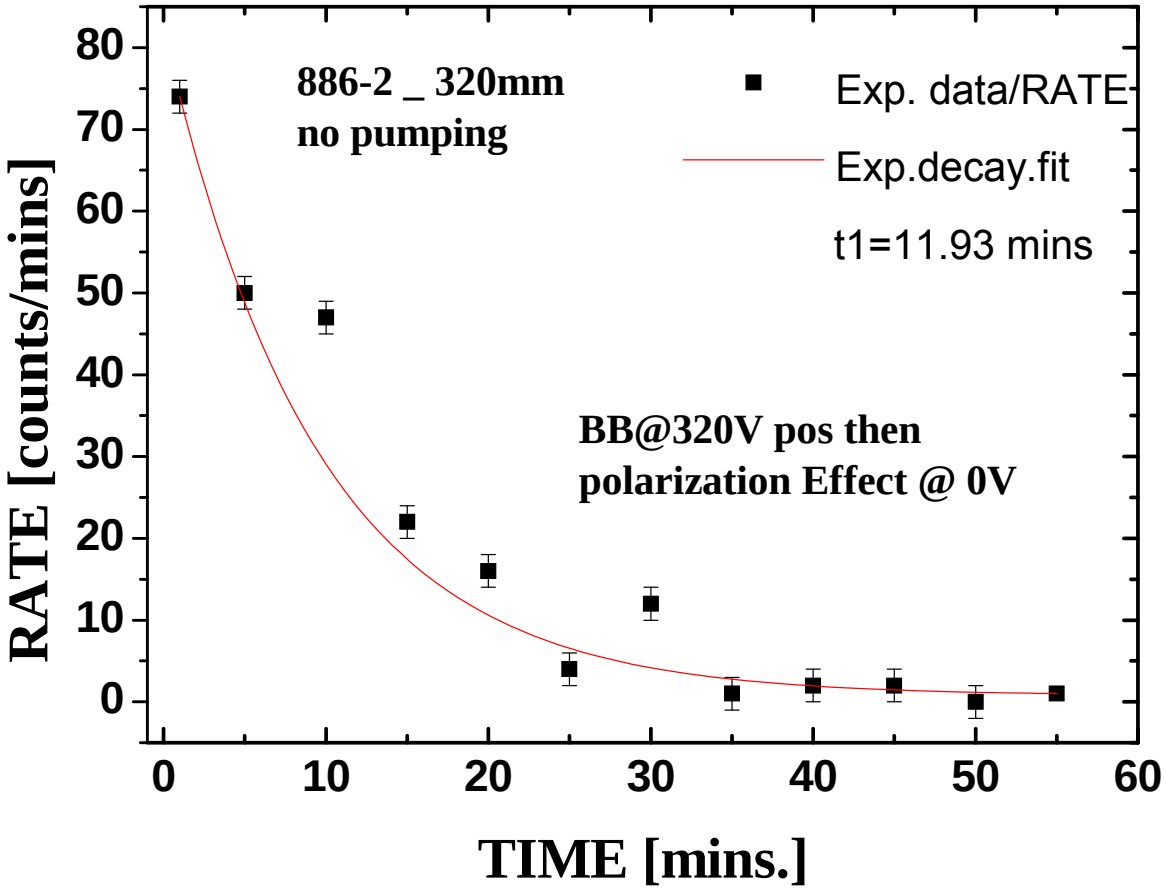


positive bias (1V/μm)



DoI 886-2 (320μm)

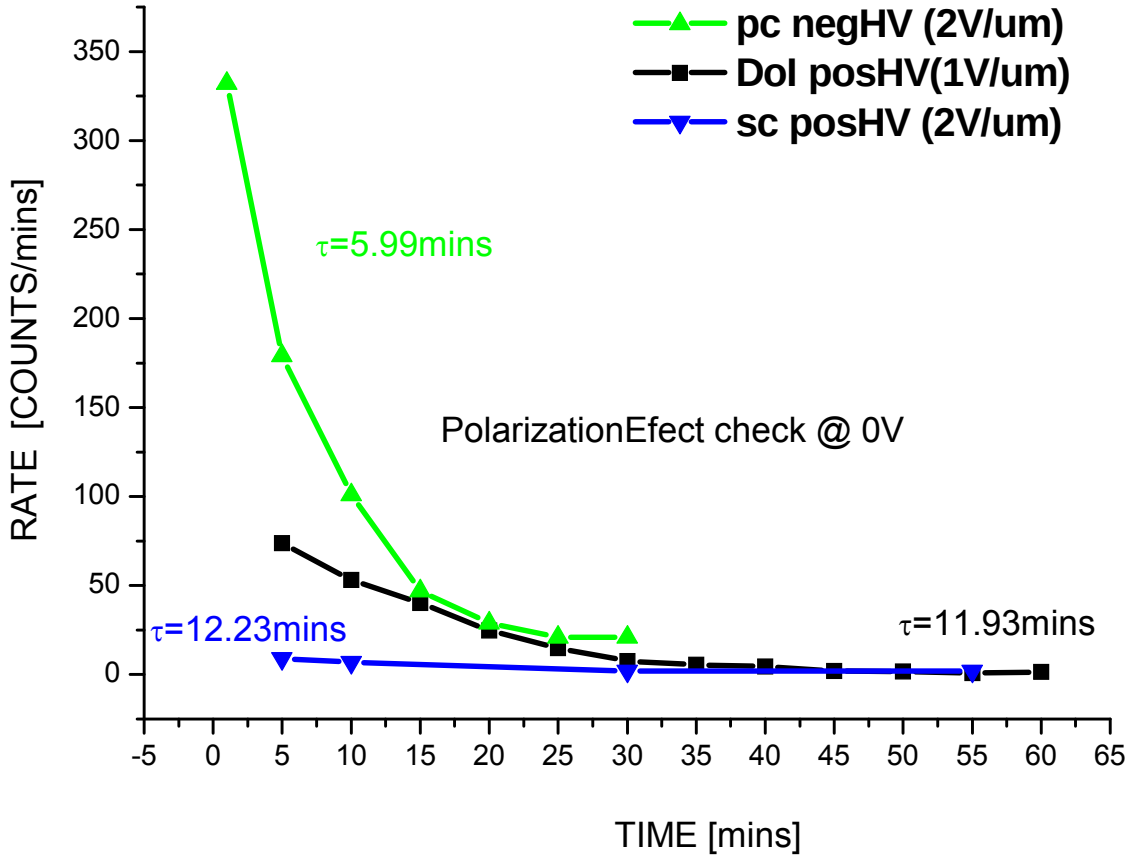
Polarization effect in DoI detectors



positive bias (1V/μm)

DoI 886-2 (320μm)

Polarization effect in different CVDD detectors



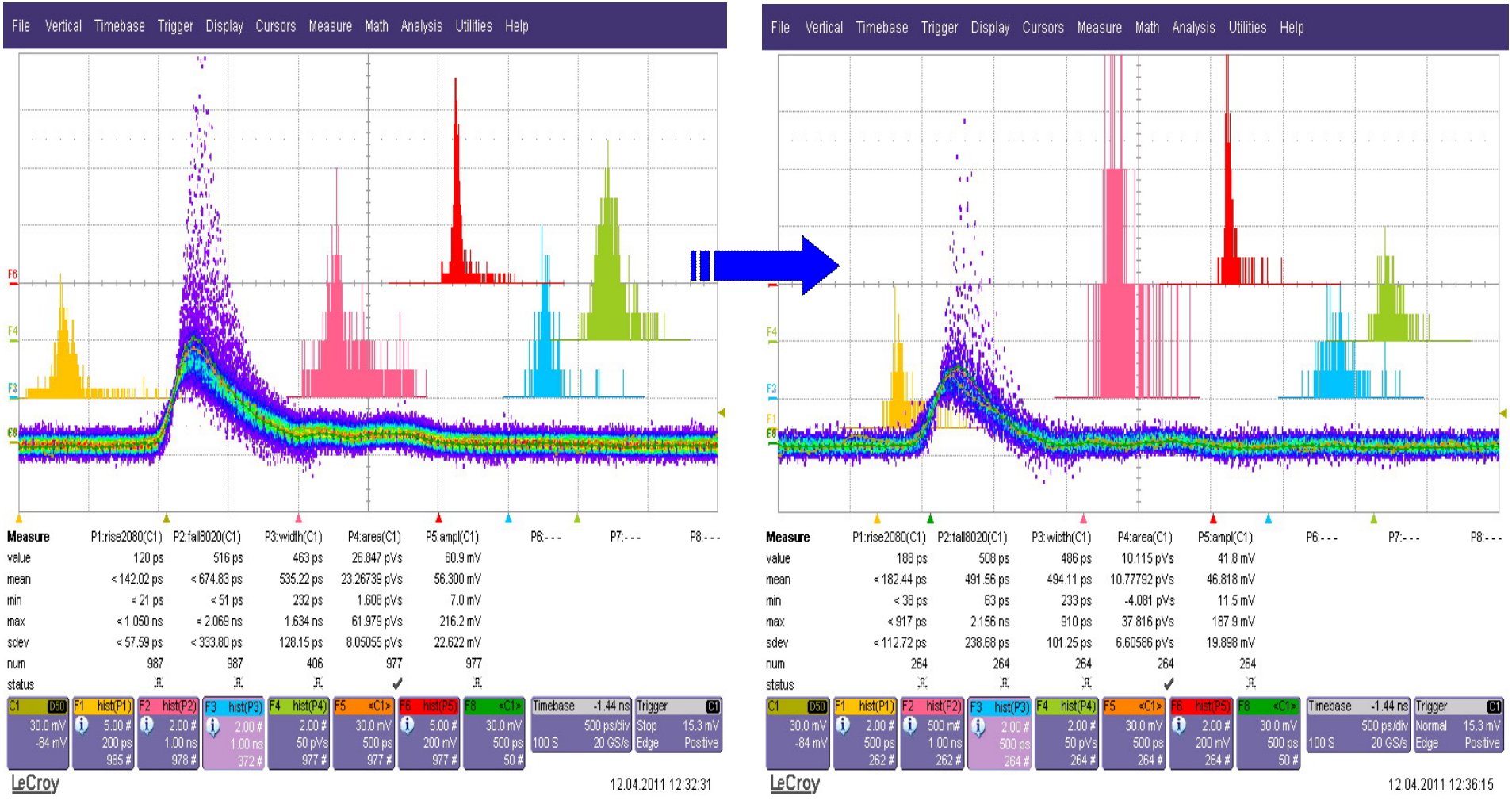
CCE of 3 different CVDDs

polarization effect is more in pc-CVDD and DoI lies between pc- and sc-CVDD detectors.

Polarization is effect are due the defects in the bulk of the diamonds

In term of the polarization effect the DoI behaves as 'quasi' sc CVDD detectors

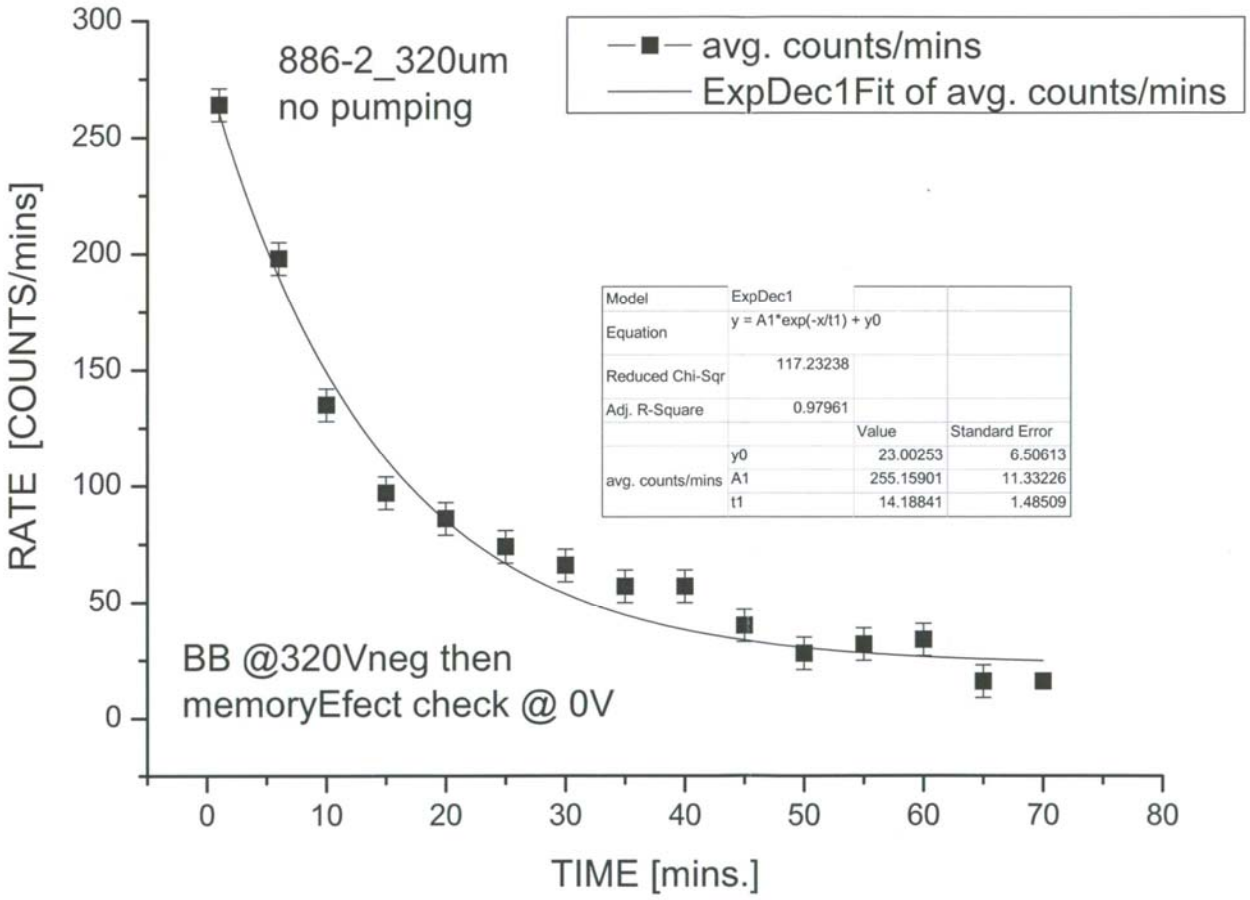
Memory effect in DoI detectors



negative bias (1V/μm)

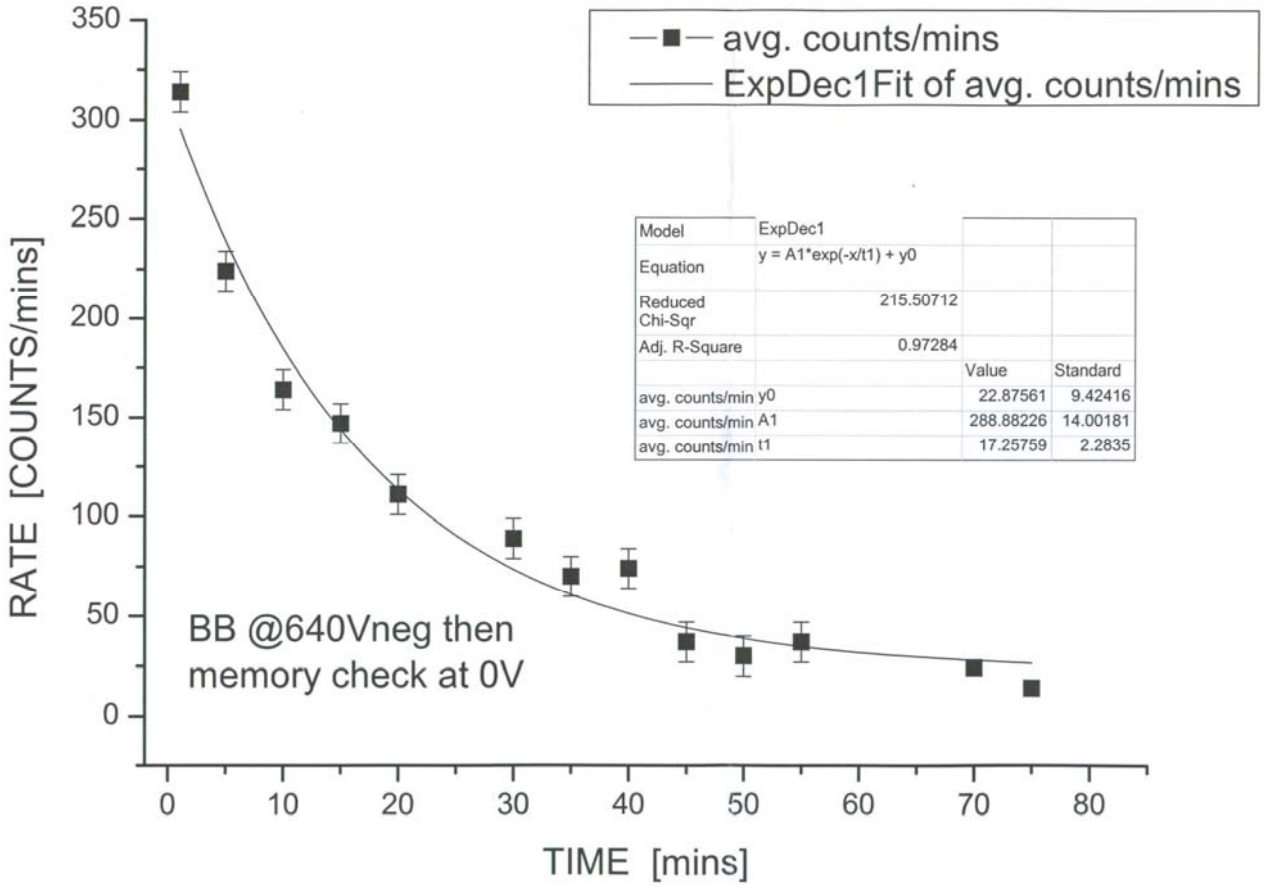
DoI 886-2 (320μm)

Memory effect in DoI detectors



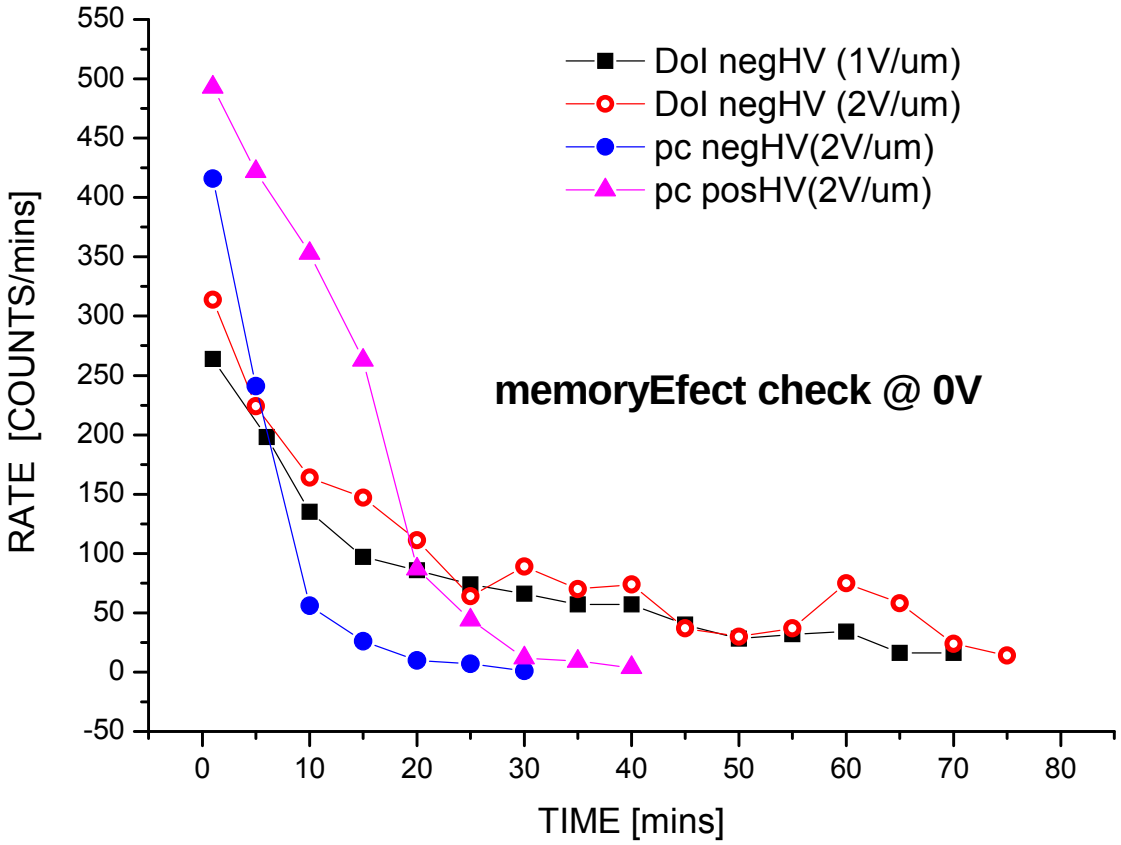
negative bias (1V/μm) ***DoI 886-2 (320μm)***

Memory effect in DoI detectors



negative bias (2V/μm) ***DoI 886-2 (320μm)***

Memory effect in different CVDD detectors



memory effect is more in pc-CVDD

In both bias condition the memory effect is similar in DoI detectors while this effect is varying in pc-diamond.

However in sc-CVDD detectors no such phenomenon is observed.

bias (>1V/μm)

CCE of 3 different CVDDs

Summaries

- **Electrical (*I-V*) characteristics of scCVDD and DoI detectors are analyzed; the dark current of DoI samples is by one order magnitude lower than the current observed with scCVDD.**

- **The main dark current conductivity in scCVDD detector is SCLC and DoI is Space Charge Limited Conduction (SCLC) and E^{ac} is 0.37~0.39eV. While for DoI the *Eac* is (1.03~1.32)eV**

- **The CEE of DoI is improved with the new DOI samples (11%→93%) also the energy resolution (18%→4%)**

- **The polarization effect is observed in DoI which lies between pcCVDD and scCVDD at positive bias while at neg. bias (V) the memory effect is visible.**

Thank you for your attention