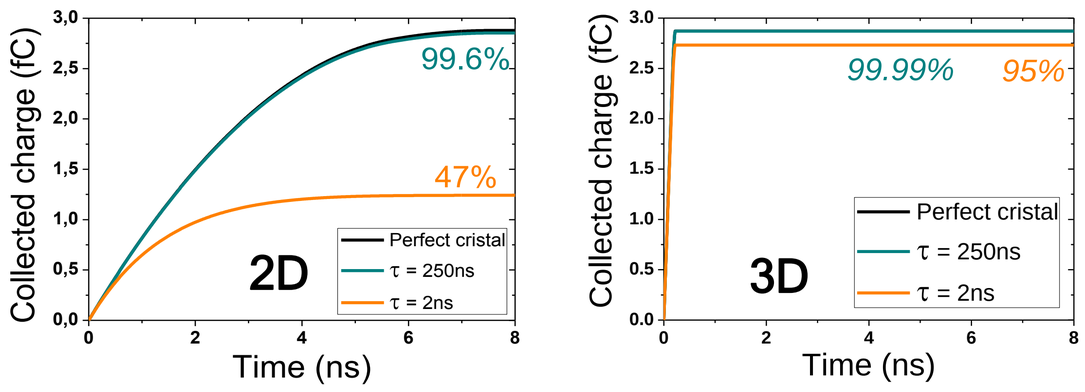
Novel 3D micro-structuring of diamond for radiation detector applications: enhanced performances evaluated under particles and photons beams.

Benoît Caylar[1], Michal Pomorski[1], Alexander Oh[2], Thorsten Wengler[3], Philippe Bergonzo[1]

[1] CEA, LIST, Diamond Sensors Laboratory, Gif-sur-Yvette, F-91191, France
[2]University of Manchester, School of Physics and Astronomy, Manchester, UK
[3] CERN, 1211 Geneva 23, Switzerland
benoit.caylar@cea.fr

Introduction

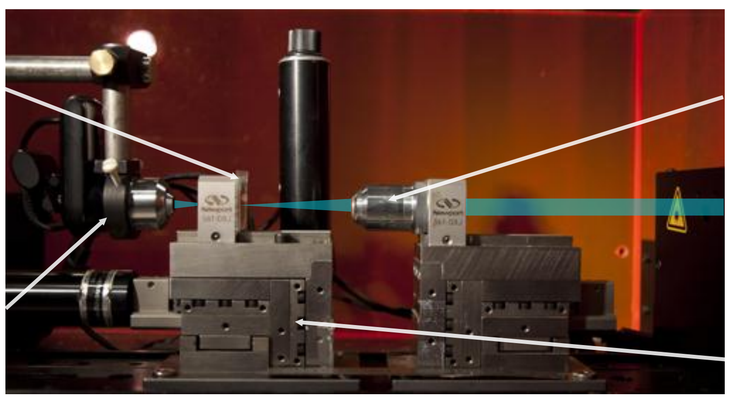
- 3D electrodes : Collecting electrodes implemented within the bulk of the diamond and separated by a few tens of microns (limited by the processing techniques).
- This geometry enables higher electric fields to be applied, thus faster drift velocities, shorter drift path of charge carriers, and a reduced probability of trapping in the detector.
- Successfully tested with silicon detectors[1] where significant improvement in radiation hardness[2] (comparable to planar diamond detectors) has been obtained.
- Here we applied the approach to diamond devices, processing 3D geometries to demonstrate the gain it brings to the performances of CVD diamond detectors.



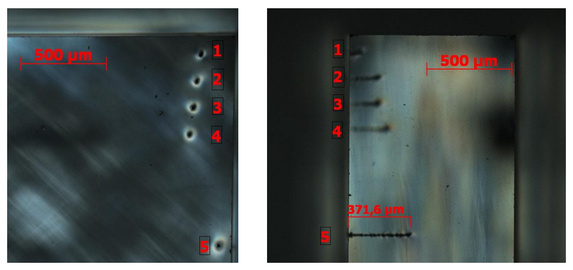
Calculated CCE for types of geometry

[1] J.Morse, C.J. Kenney, E.M. Westbrook et al. / Nuclear Instruments and Methods in Physics Research Section A, vol.524 (2004) p.236.
[2] C. Da Viá, J. Hasi, C. Kenney et al. / Nuclear Instruments and Methods in Physics Research Section A, vol.587 (2008) p.243.

Electrodes fabrication and characterization

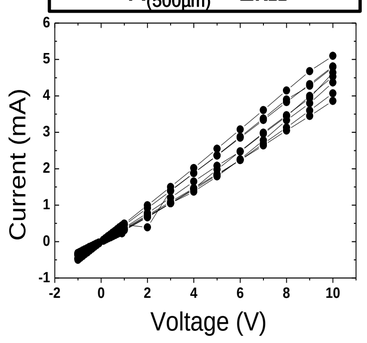


$\varnothing_{min}$= 20 µm $Pitch_{min}$=150 µm



Optical microscopy using crossed polarizers

$\rho = 5.7 \times 10^{-1}\ \Omega.cm$
$R_{(500\mu m)} \sim 2k\Omega$

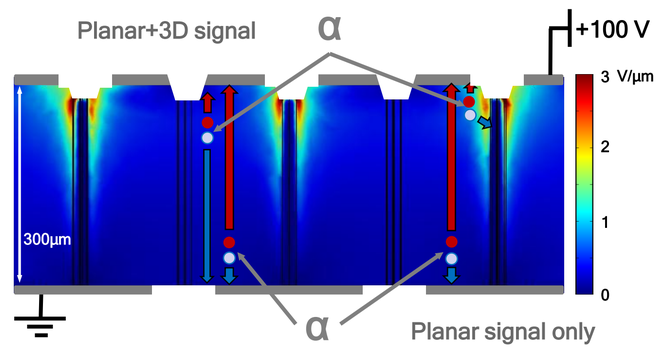


Match with nanocrystalline graphite's resitivity given in literature[3]

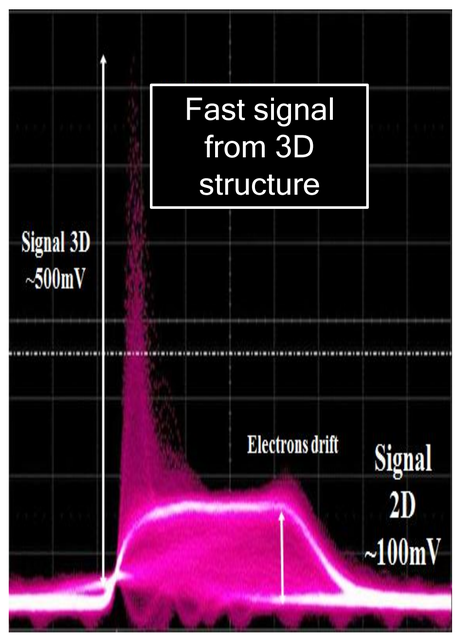
[3] T.Ohana, T.Nakamura, A.Goto et al. / Diamond and Related Materials, vol.12 (2003) p.2011.

Results and discussion

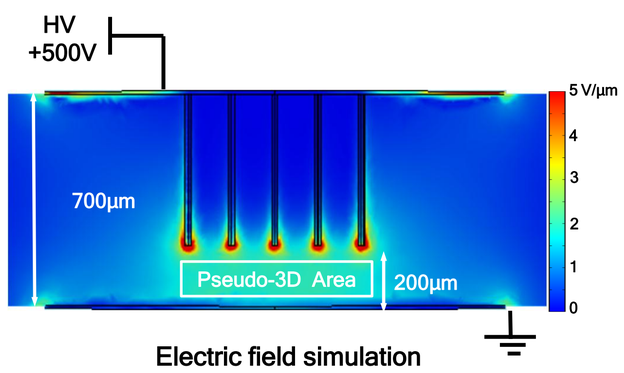
Transient currents measured on a sc-CVD sample (5,5 MeV α -particles)



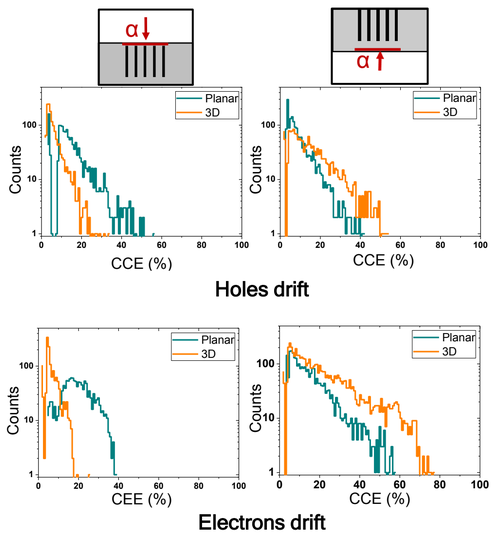
Electric field simulation



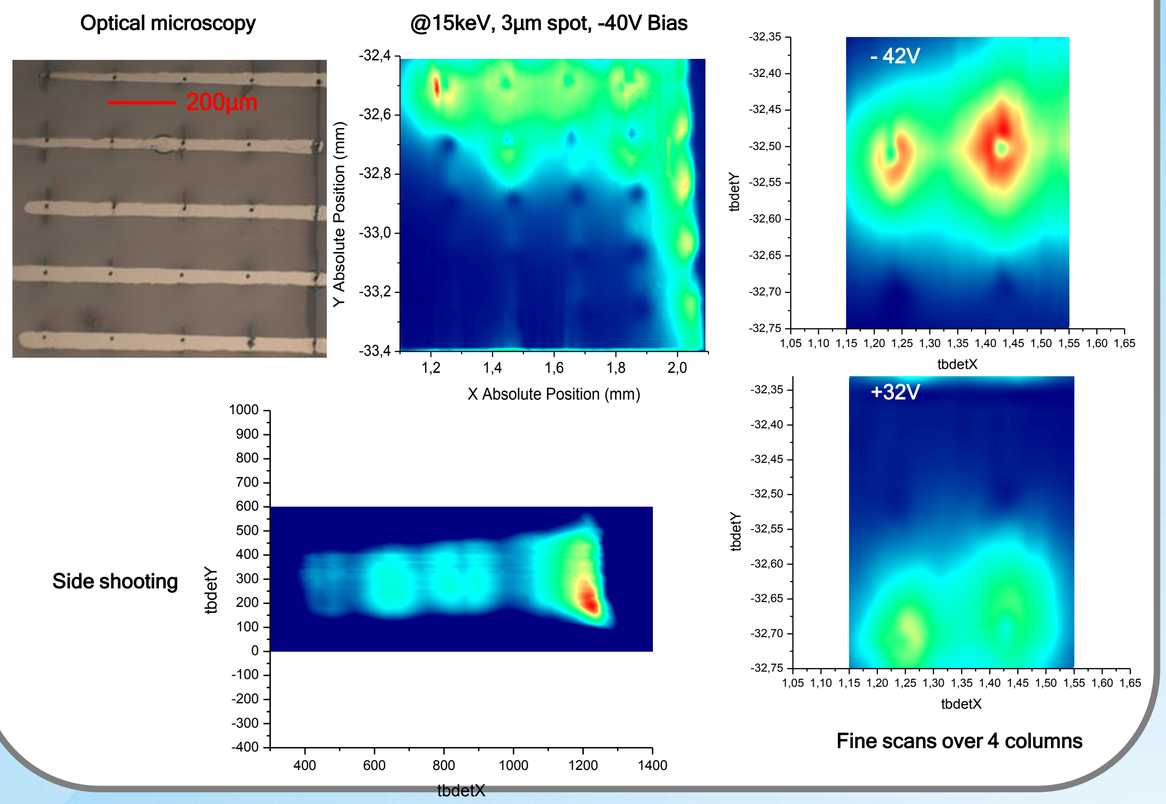
CCE measured on a pc-CVD sample (5,5 MeV α -particles)



Electric field simulation



Synchrotron micro-beam mapping of a sc-CVD sample



Conclusion

- First 3D diamond prototypes
- Laser graphitization is a good way to achieve 3D diamond detector.
- Produced graphitic structures are conductive and suitable for detectors applications.
- Still experiencing processing problems because of internal
- We are now thinking about using a femtosecond rather than nanosecond laser which shows very good results elsewhere[4].

[4] T.V. Kononenko et al. / Diamond & Related Materials 20 (2011) 264-268