Advanced Diamond Detectors at LCD

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Co-Authors, Co-Workers

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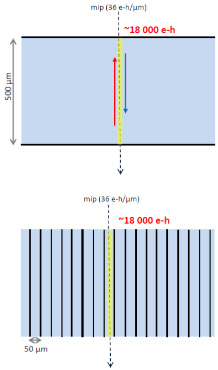
- ESRF John Morse
- SOLEIL SYNCHROTRON Kewin Desjardins, Stephanie Hustache
- Natko Skukan, Veljko Grilj, Milko Jaksic SPIRIT

Outline

Why 3D Geometry



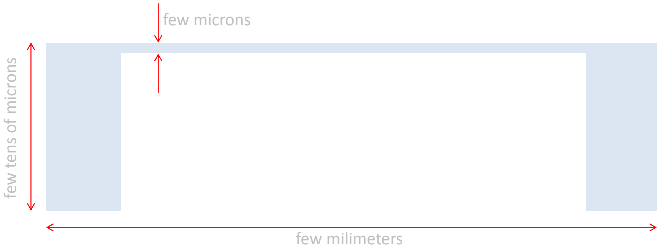
3D vs pad sandwich detector

PAD
E $= 1$ V$/\mu$m
e V $= 66$ μm$/$ns
h V $= 88$ μm$/$ns
pulse t $= 7.57$ ns
pulse A $= 0.89$ μA

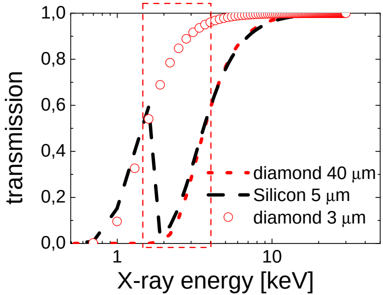
3D
E $= 5$ V$/\mu$m
e V $= 120$ μm$/$ns
h V $= 130$ μm$/$ns
pulse t $= 416$ ps
pulse A $= 14.5$ μA

more in the next talk...

Super-Thin scCVD

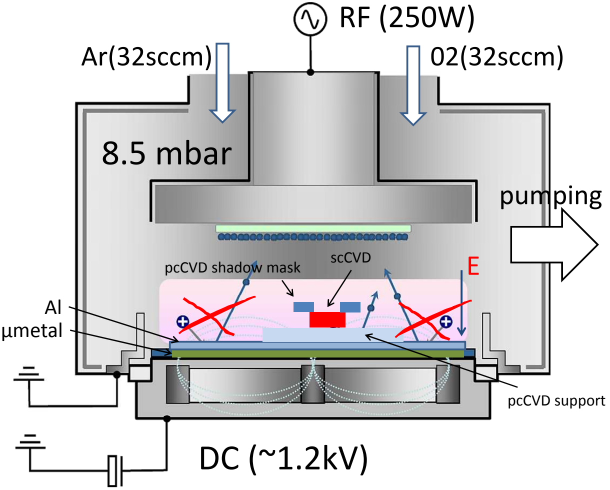


Motivation

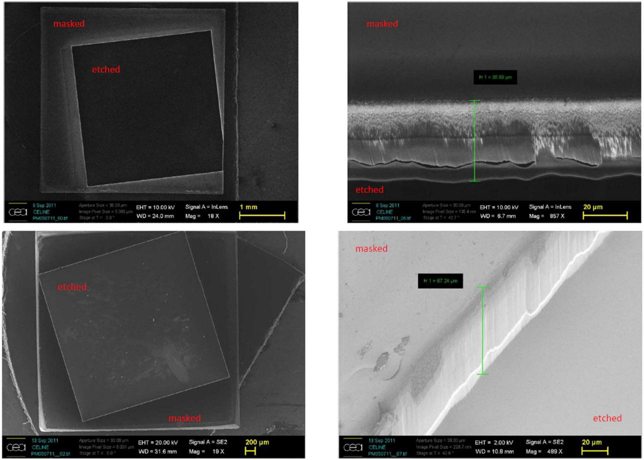


- low energy X-ray lines XBPM (Soleil, ESRF ... others if works)
- low energy ions, ΔE detector + vacuum window (IRB, Zagreb)

ArO Plasma Etching in Magnetron PVD

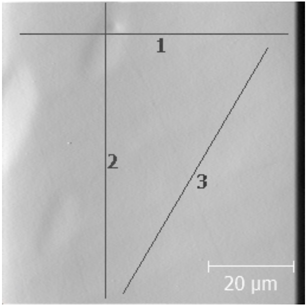


SEM Photos of Deep-Etch

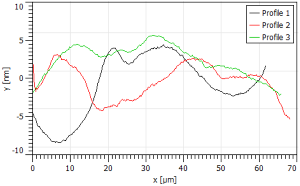


two squared grooves: 49μm (top) and 68 μm (bottom) deep, etched in 600 μm thick scCVD Apollo diamond. Etching rate 0.95 μm/h

Surfaces Quality After Deep-Etch - AFM

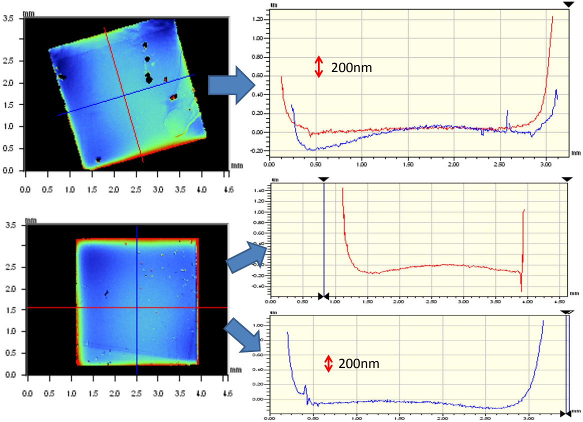


AFM surface topography after 49 μm deep etch



corresponding profiles

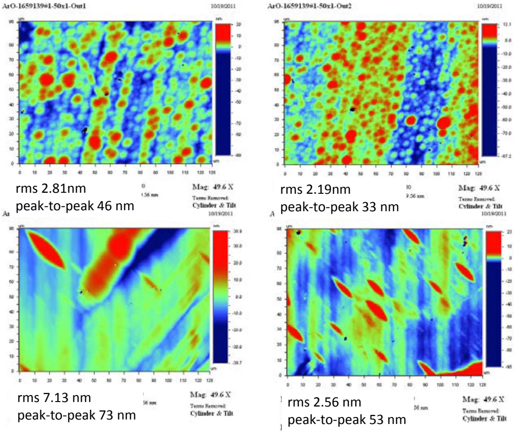
Global Surface Quality by Laser Interferometry



(top) 49 μm deep groove, (bottom) 68 μm deep groove. Laser interfermometry measurements courtesy A. Vivo (ESRF).

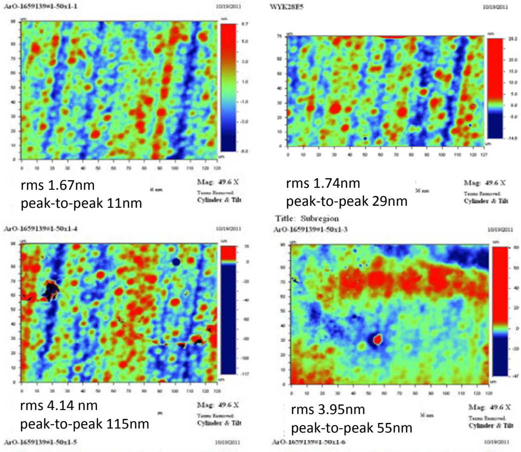
Local Surface Quality by Laser Interferometry

Masked area (not exposed to plasma)



Local Surface Quality by Laser Interferometry

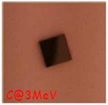
Etched area



The Smart-Cut

HPHT super-polished substarte

ion implantation



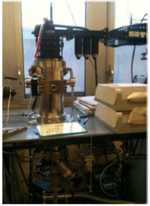
ion implantation, thanks to Natko Skukan, IRB, Zagreb, Croatia

CVD growth

E

bi-polar etching

5269890 United States Patent, Marchywka 1993



CVD
Surface preparation :
Plasma H2 : 20 minutes
100 mbar, 850 °C,
DH2= 333 sccm, 550 Watts
Growth: 20 hours
120 mbar
850 °C,
CH4(4sccm)/H2(400sccm) = 1 %
600 Watts

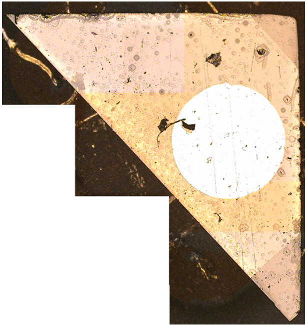
CVD film

Ar/O plasma selective etching

free standing ultra-thin scCVD films

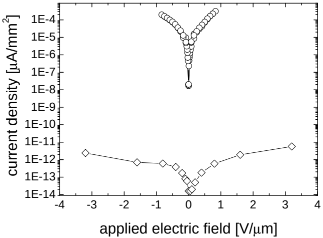
First Super Thin scCVD Films

a free-standing 20 μm thick scCVD grown in ASTEX reactor (intrinsic). Crossed polarizers image. Electrode diameter 1 mm



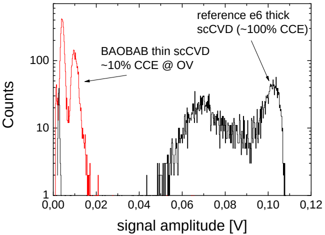
a free-standing 10 μm thick scCVD grown in BAOBAB reactor (boron contaminated). Electrode diameter 1 mm

Electrical Characterisation



I-E(V) characteristics. Keithley electrometer. open circles - BAOBAB scCVD

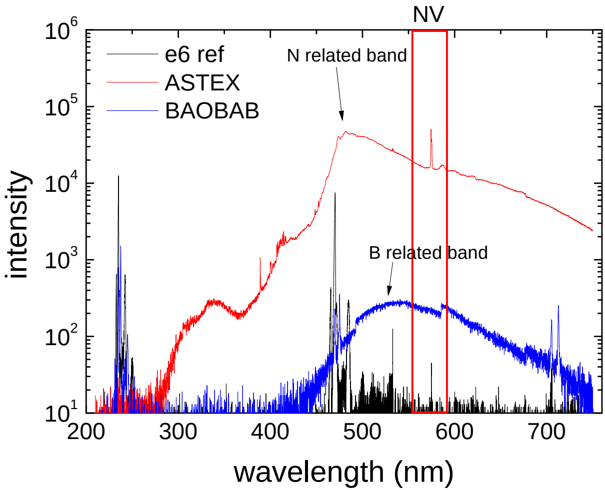
open diamonds - ASTEX scCVD



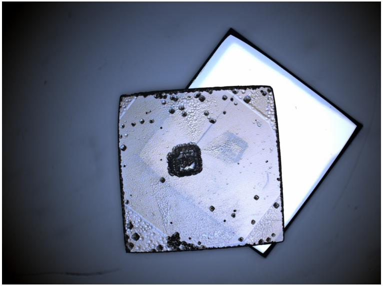
Charge Collection. 5 MeV (meas. in air) ^{241}Am α particles, FCSA designed by M.Ciobanu. red - BAOBAB scCVD

no signal for ASTEX scCVD

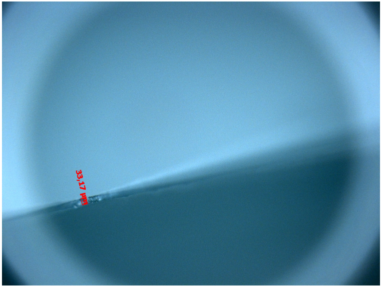
Cathodoluminescence



Recently Smart-Cut Thin scCVD

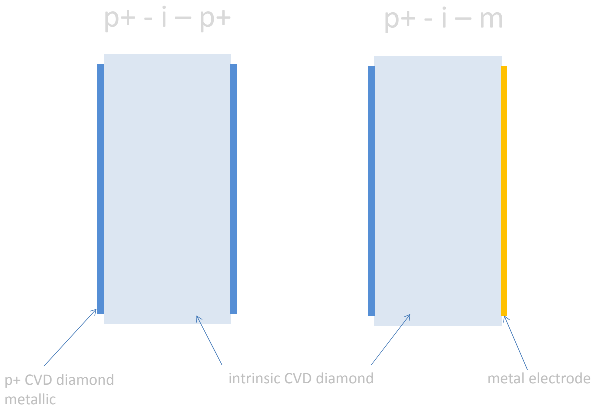


A scCVD 3 x 3 mm just after electrochemical etch. The large defect in the center was induced in HPHT seed crystal by a hurried laser marking prior to the CVD growth

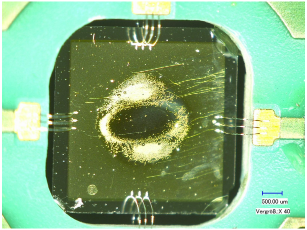


A side view of a free-standing scCVD: thickness about 33 μm

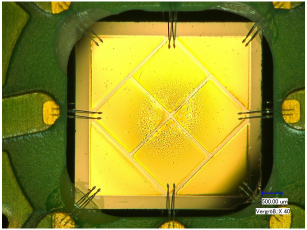
p+-i-p+ and p+-i-m Structures in scCVD



Motivation



HADES scCVD start detector. Back contact damage after intense Au beam (both photos courtesy Jerzy Pietraszko)



HADES scCVD start detector Front contact damage after intense Au beam

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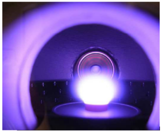
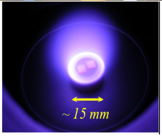
- robust fully-diamond detectors
- resistive electrode PSD
- medical dosimetry

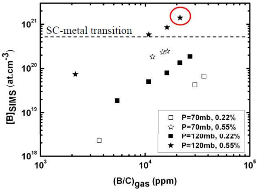
CVD Growth of scCVD p+ Layers





metal-wall MWCVD reactor

$$[CH4] / [H2] = 0.55\ \%$$
$$(B/C)_{gas} = 2\ \ 10^4\ \text{ppm}$$
$$\text{Power} = 438\ \text{W}$$
$$\text{P} = 120\ \text{mbar}$$
$$\text{T} = 870\ \text{C}$$



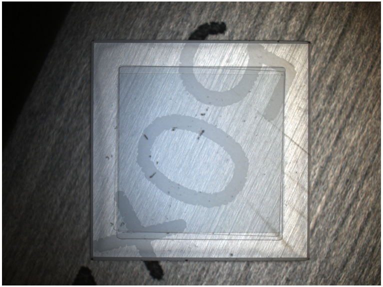
after the growth selective ArO plasma etching

possibility of patterning using

photolithography and Al masking

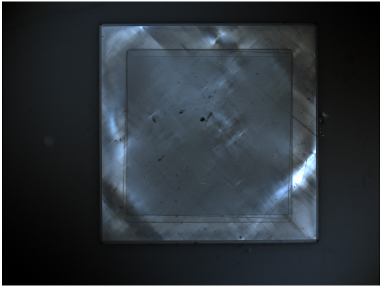
p+-i-p+ Pad Detector

no more scratched electrodes !



p+-i-p+ device

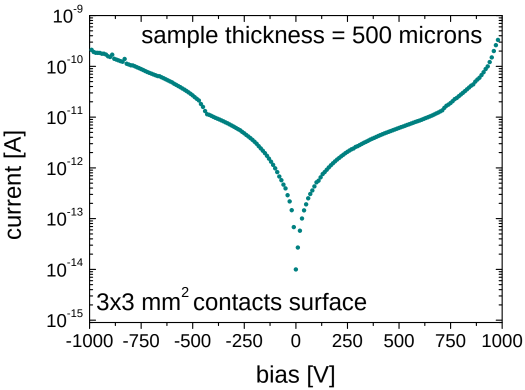
500μm scCVD e6 electronic grade + two higly boron-doped CVD diamond 200nm contacts



the same p+-i-p+ device with crossed polarizers

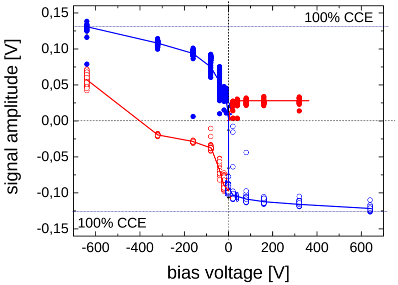
I-V Characteristics

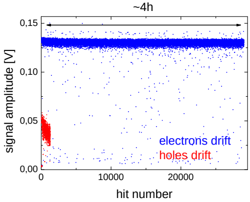
leakage current ok for detector application



Charge Collection Properties

5 MeV (meas. in air) ^{241}Am α particles injection, FCSA designed by M.Ciobanu

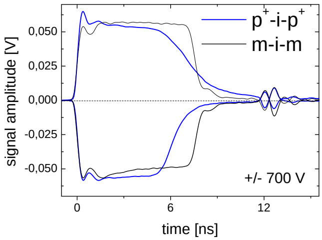


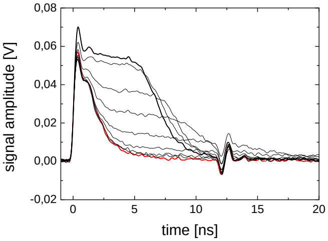


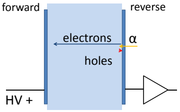
detector stability at -700V

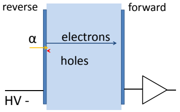
Transient Currents in Non-Blocking Regime

5 MeV (meas. in air) ^{241}Am α particles injection, CIVIDEC 50 Ω current amplifier



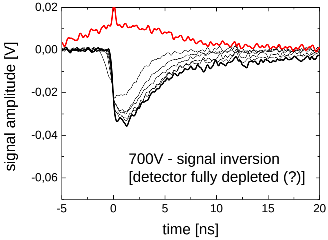




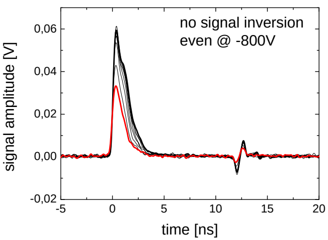


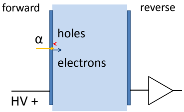
Transient Currents in Blocking Regime

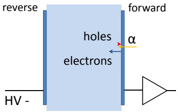
positive TC expected



negative TC expected

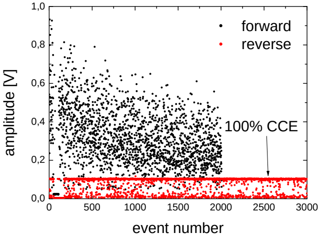


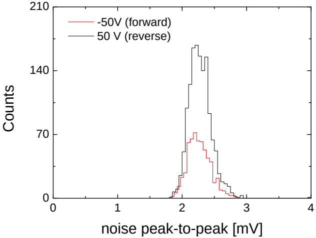




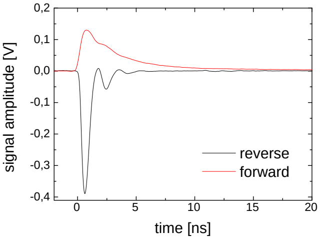
Thin p+-i-m Device - Amplification CCE

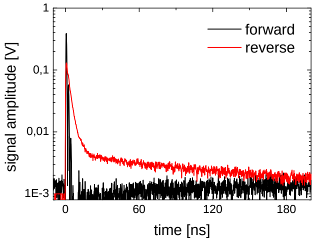
A 50 μ m thick scCVD with one p+ boron doped and one Al contacts shows signal amplification in forward regime





Thin p+-i-m Device - Amplification TCT





rather photoconductive gain (charge injection from contacts) than avalanche

Summary

- Ar0 plasma etching seems to be promising for scCVD membranes fabrication using commercially available electronic grade scCVDs: detectors comming sooon
- First super-thin scCVD samples were obatained using Smart-Cut Technique: electronic grade(hope) comming soon
- first scCVD p+-i-p+ fully-diamond pad detector fabricated, stable operation for α particle source demonstrated
- signal amplification (not stable) in forward mode scCVD p+-i-m opearted device: needs detailed examination

Growing Conductive Paths on Diamond Surfaces

Creating electrical contacts between metal particles using directed electrochemical growth

Jean-Claude Bradley, Hsuing-Ming Chen, Jeffrey Crawford, Jennifer Eckert, Karima Ernazarova, Thomas Kurzeja, Muduo Lin, Michael McGee, Wolfgang Nadler & Samuel G. Stephens

Drexel University, Department of Chemistry, 32nd and Chestnut Streets, Philadelphia, Pennsylvania 19104, USA

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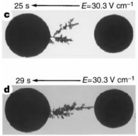
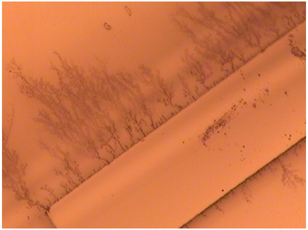
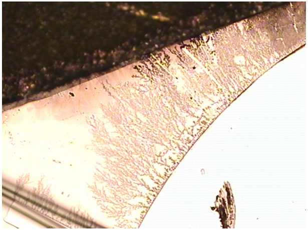


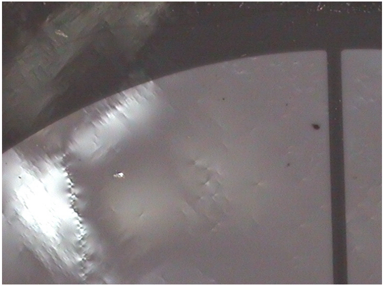


scCVD XBPM operated few days at Soleil in ambient condition



scCVD XBPM operated few days at Soleil in ambient conditions

Enhanced Contrast for Crossed-polar Imaging



Al back metalization enhaces crossed-polarizers contrast

single threading dislocations in 50 μm thick scCVD diamond visible