



Silicon On Diamond Devices



istituto italiano di tecnologia

(A Chip On Diamond Project)

Silvio Sciortino

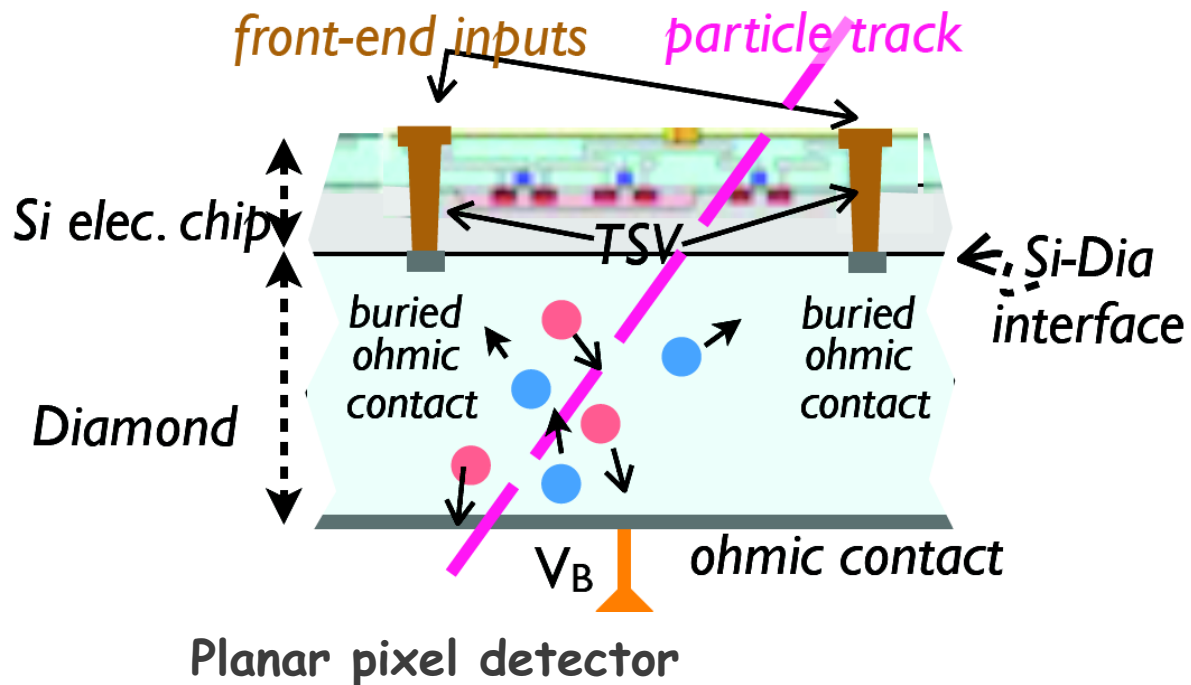
for the CHIPSODIA Collaboration

*National Institute for Nuclear Physics (INFN)
and & Italian Institute of Technology (IIT)*

CARAT 3rd WS, GSI Darmstadt, December 13th 2011

A quick look at CHIPSODIA

Giuliano Parrini et al.,
Laser graphitization for polarization of diamond Sensors,
*10th International Conference on Large Scale Applications and Radiation
Hardness of Semiconductor Detectors, Firenze, Italy
July 6-8, 2011, in press in Proceedings of Science*

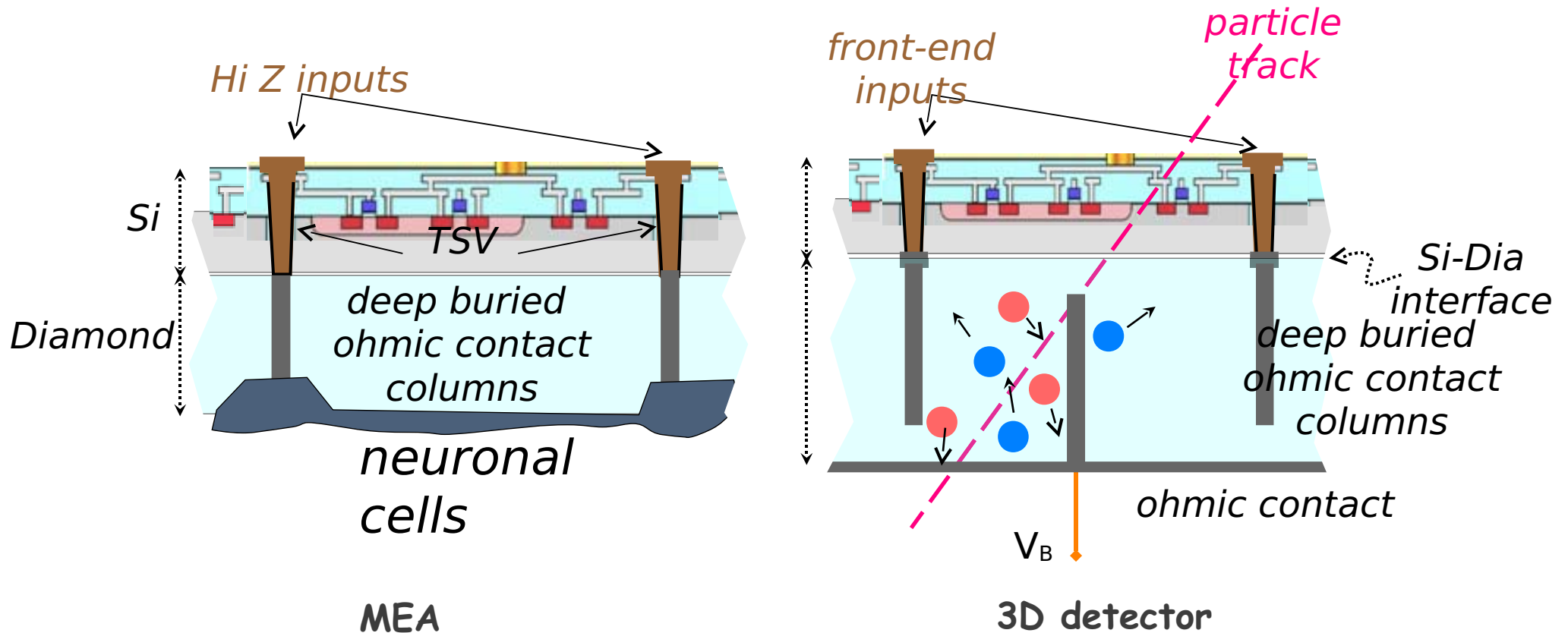


The TSVs connect the electronics inputs with the buried contacts at the Si-Dia interface. Not to scale. Expected values are: $\approx 50 \mu\text{m}$ (pitch), $\approx 50 \div 500 \mu\text{m}$ (Diamond thickness) and $\approx 50 \mu\text{m}$ (Si thickness).

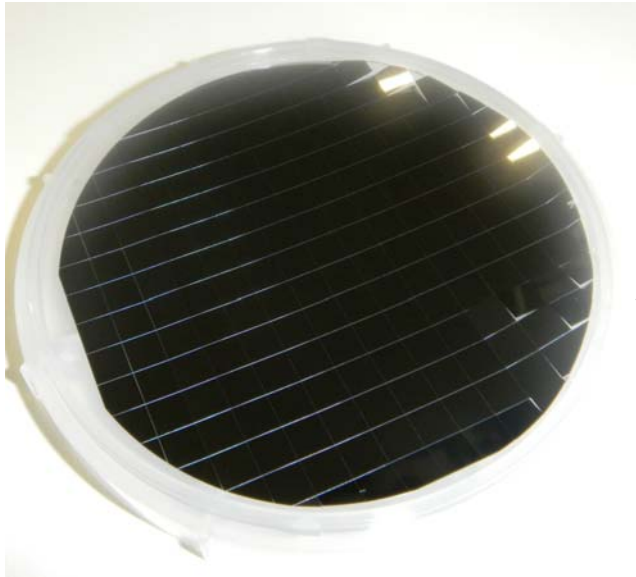
A quick look at CHIPSODIA

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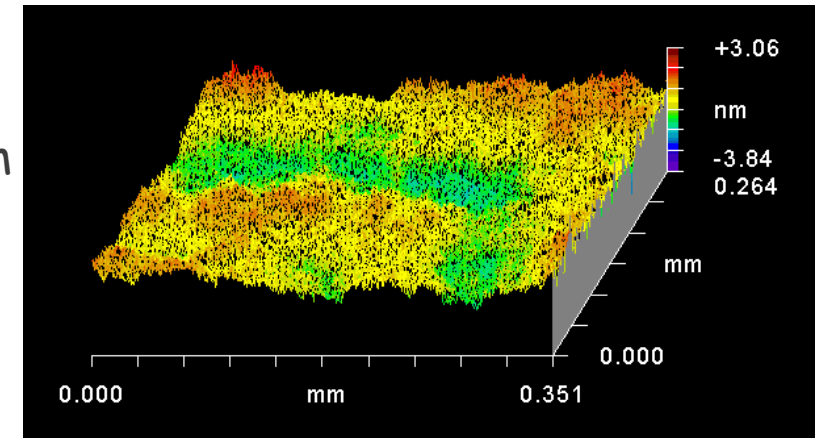
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Silicon On Diamond Fabrication: **Si & D** samples

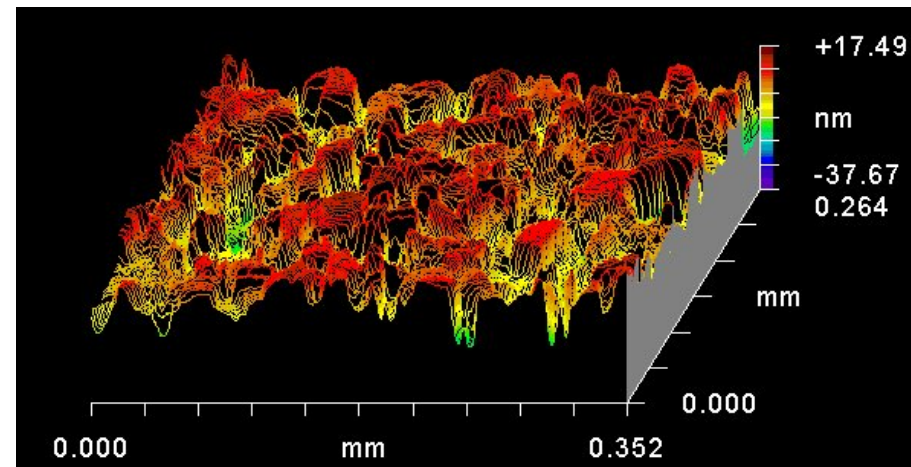
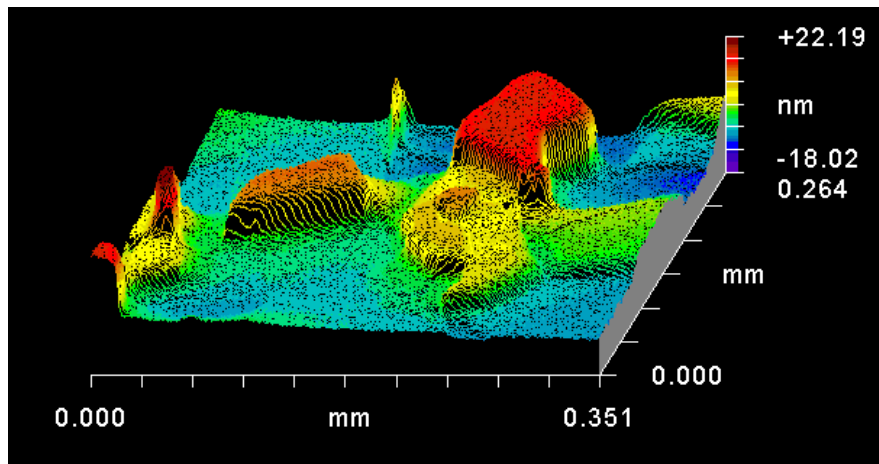


Si wafer cut in
5 × 5 mm² plates
Thickness from 270 to 90 μm
 $\rho = 1 \text{ k}\Omega \text{ cm} \rightarrow 10 \text{ }\Omega \text{ cm}$
Roughness ~1 nm

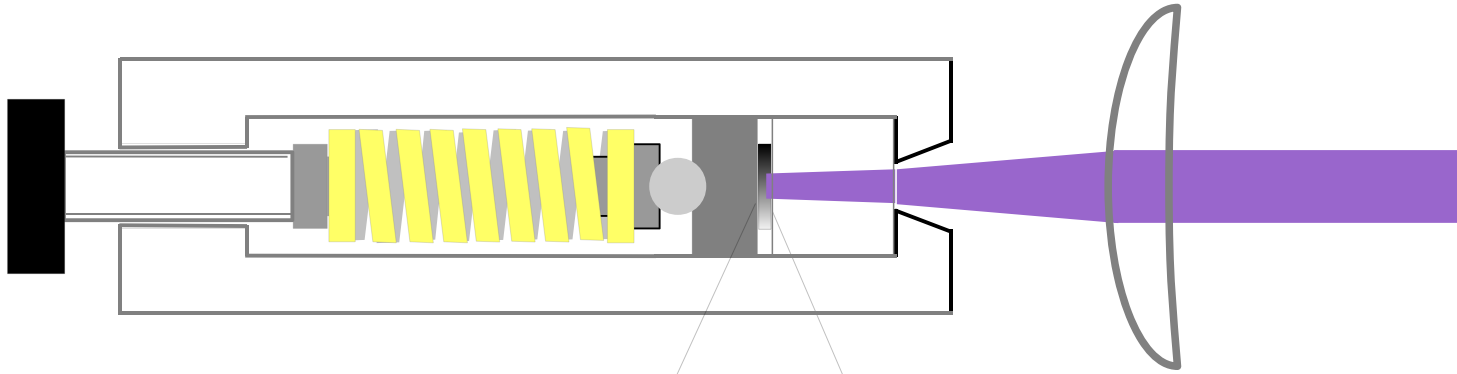


Diamond polyCVD 5 × 5 mm² plates
from DDL Ltd
Thickness from 500 to 50 μm
Roughness **5 nm at best**
Some scCVD plates recently available

**bad aspect ratio on the nucleation side for
optical grade samples**

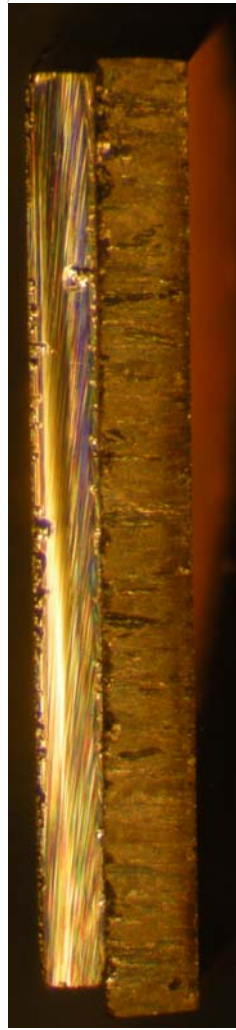


Silicon On Diamond Fabrication: **Laser bonding**



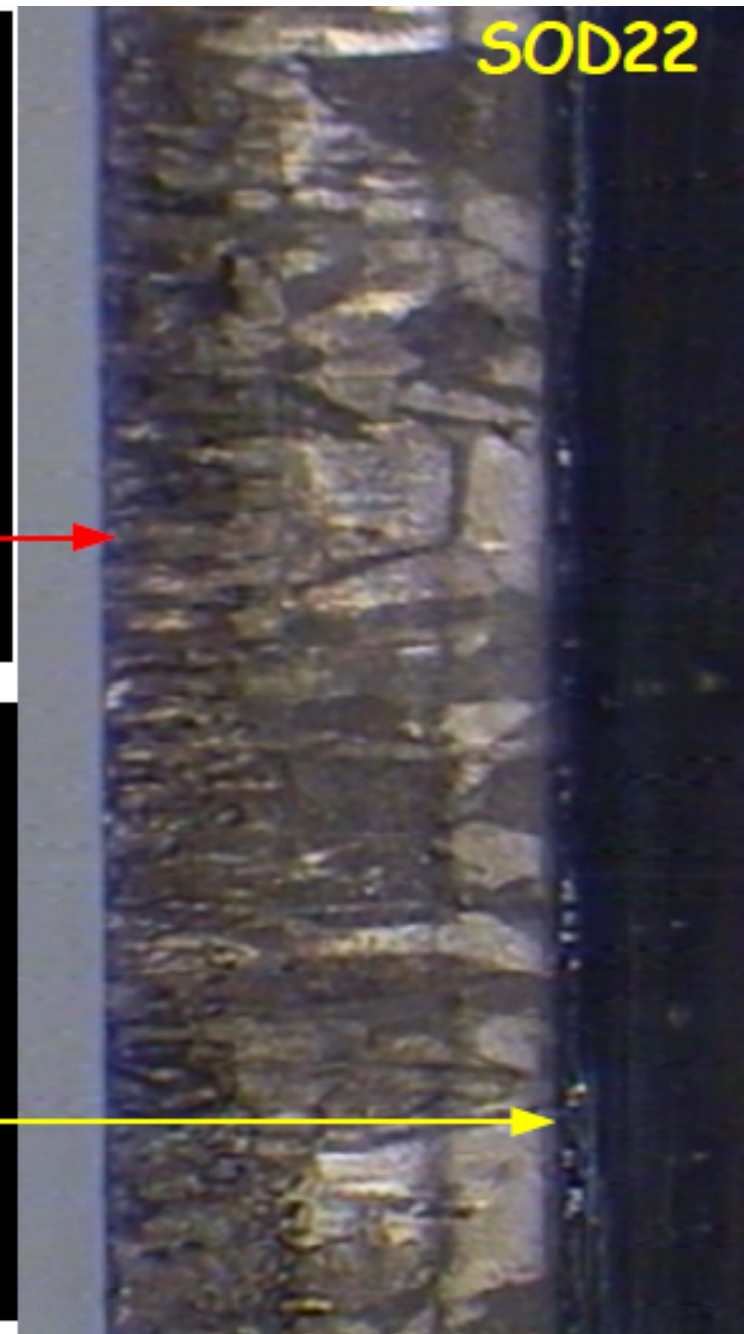
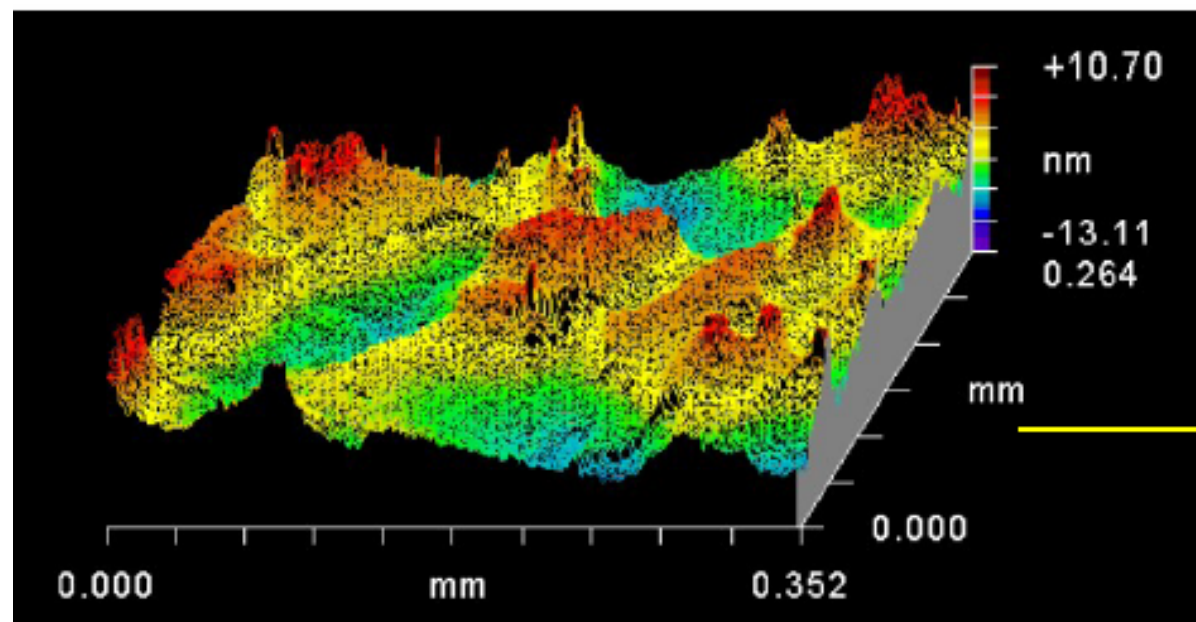
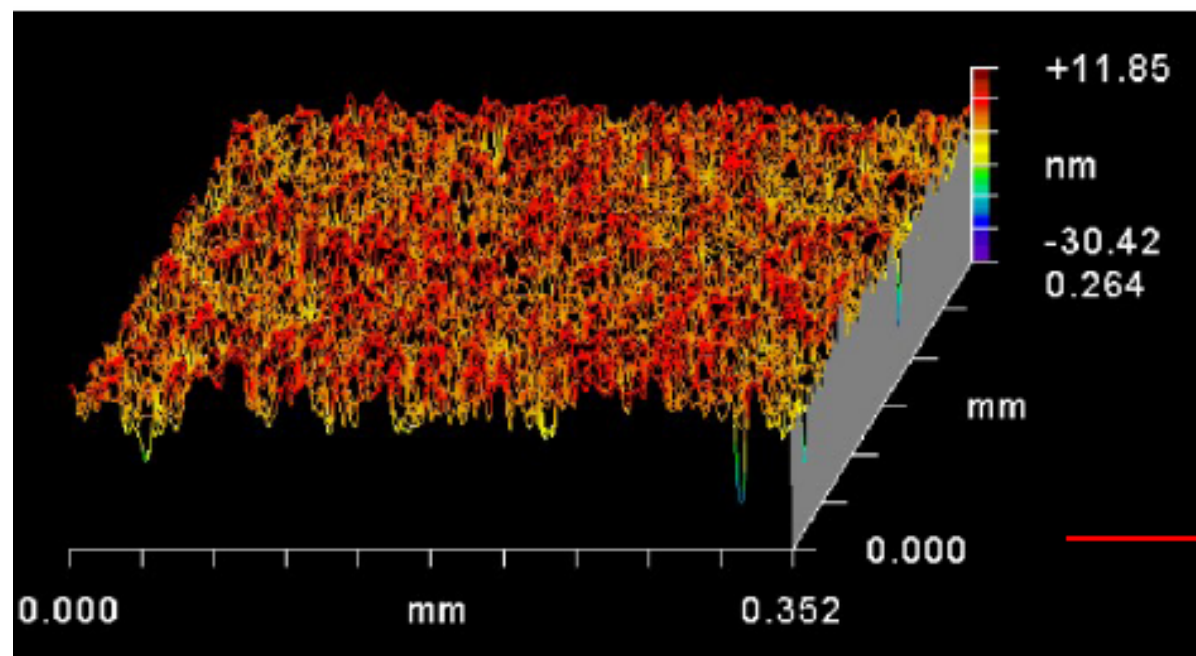
Uniaxial stress: **800 atm**
needed* for 90 % adhesion
with the present $R_a \sim 5 \text{ nm}$

*Stefano Lagomarsino Ph,D
Thesis
http://hep.fi.infn.it/sciortino/Research/dissertation_Lagomarsino.pdf



Si & D plates are cleaned in a white
chamber in ultrasonic bath
assembled in a laminar flow hood

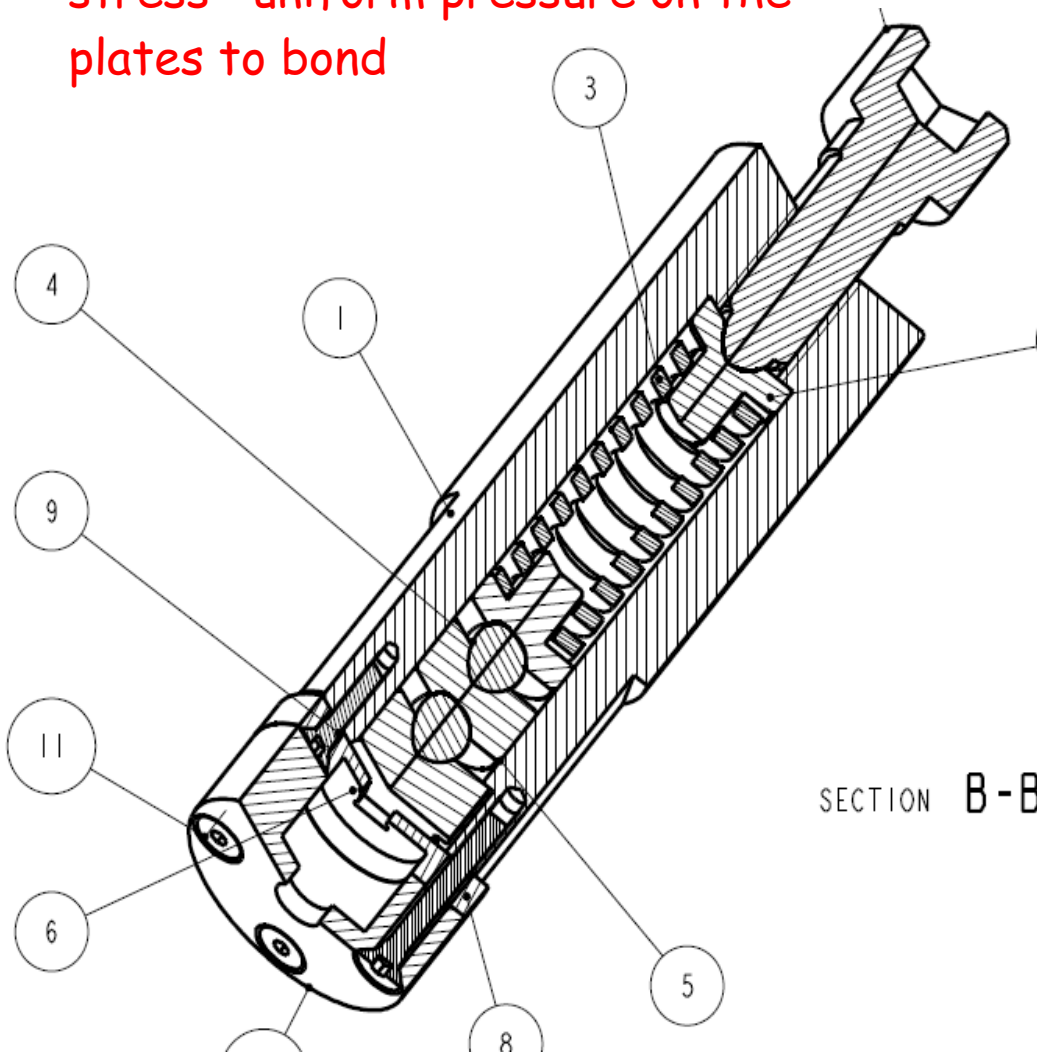
The diamond silicon interface is
irradiated by UV laser pulses
 $\lambda = 355 \text{ nm}$
 $\tau = 20 \text{ ps}$
Energy density = $2-0.5 \text{ J/cm}^2$



ASSEMBLY IMPLEMENTED BY IIT
(3rd version just released)

Ease to manipulate and assemble
pieces

Particular care in ensuring uniaxial
stress—uniform pressure on the
plates to bond

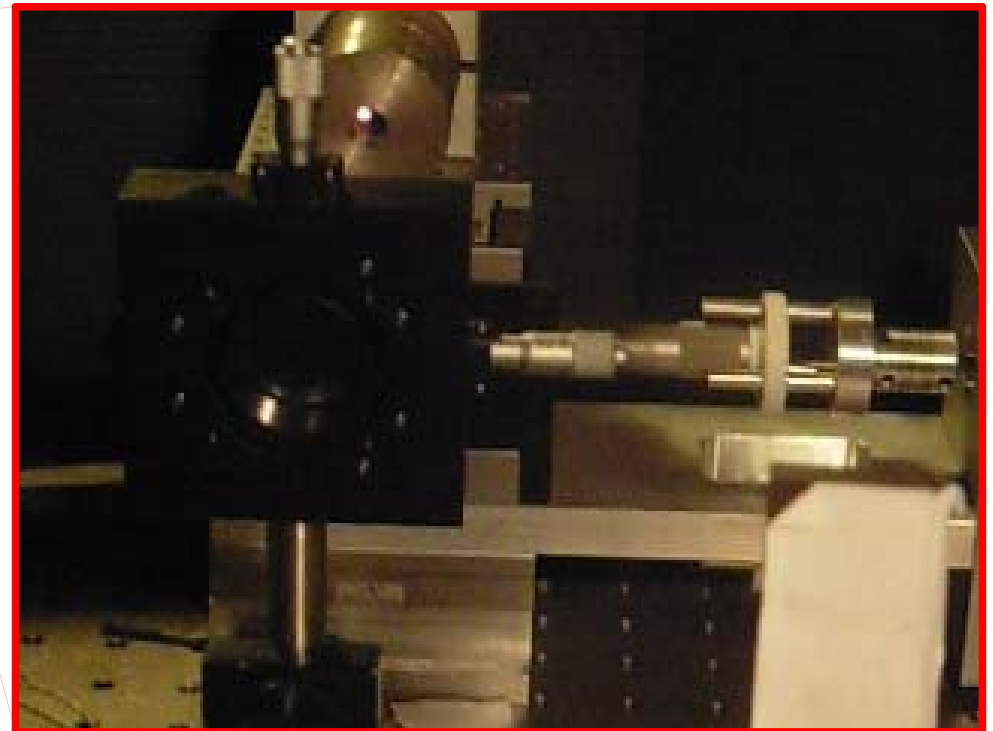


SECTION B-B



Silicon On Diamond Fabrication: **Improvements in 2011**

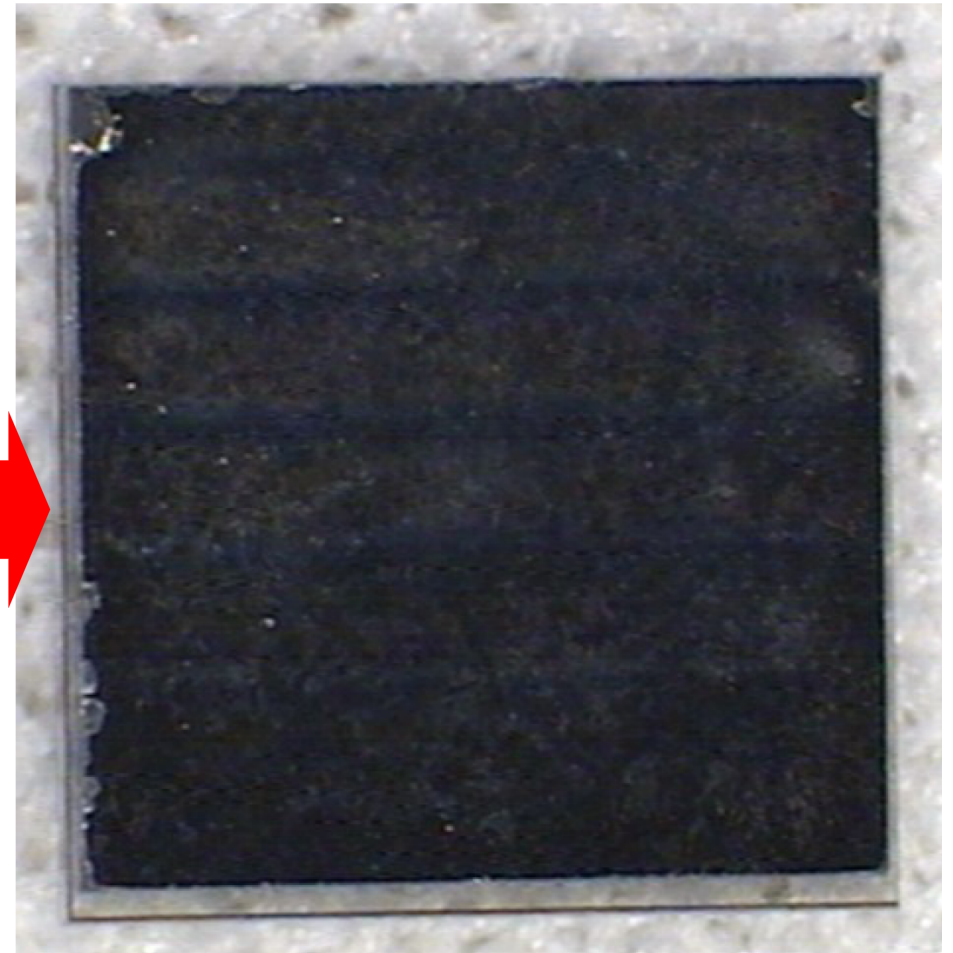
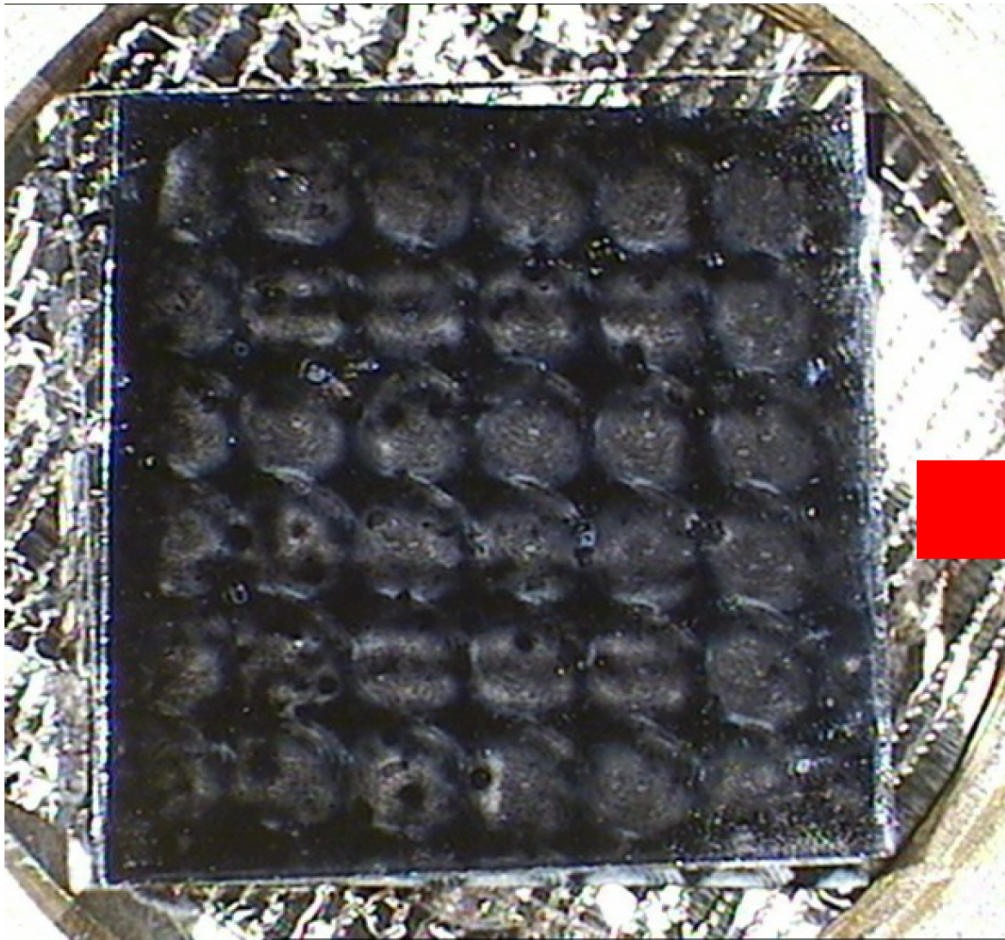
- Better cleaning procedure
- Automated continuous scanning of the laser beam



Silicon On Diamond Fabrication: **Improvements in 2011**

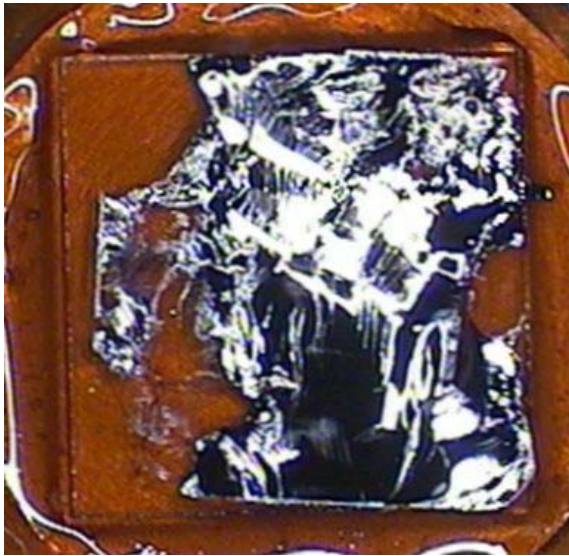
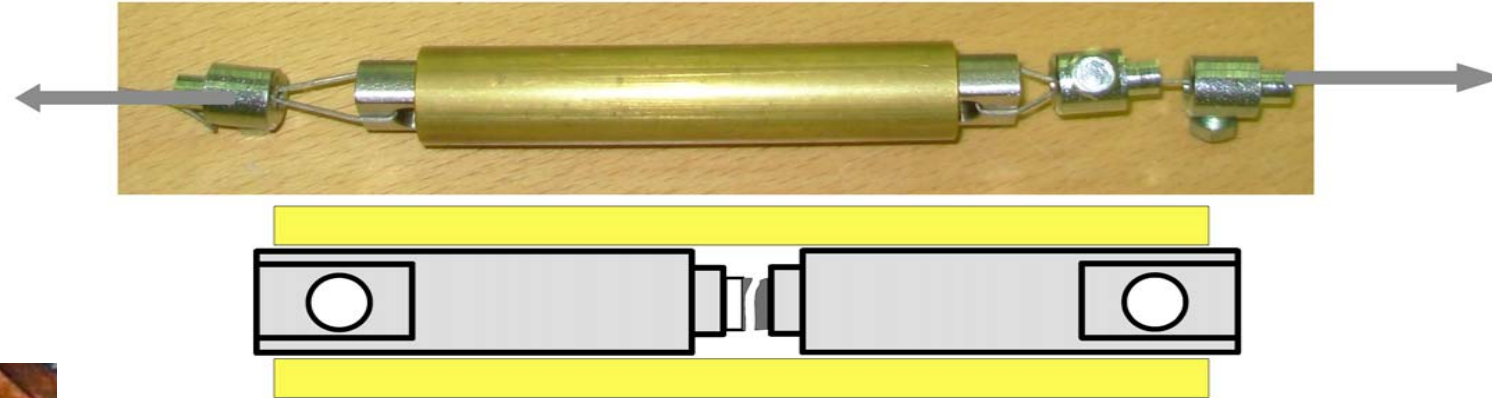
- More uniform illumination of the sample with continuous scanning

Spot on target 0.9 mm
16 shots per mm on a row
Row separated by 0.7 mm
Energy density 0.5 J/cm²

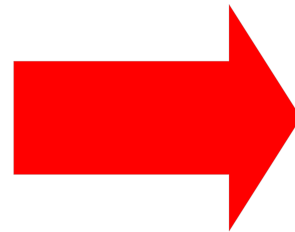


SOD12 OCTOBER 2009 & SOD23 JUNE 2011

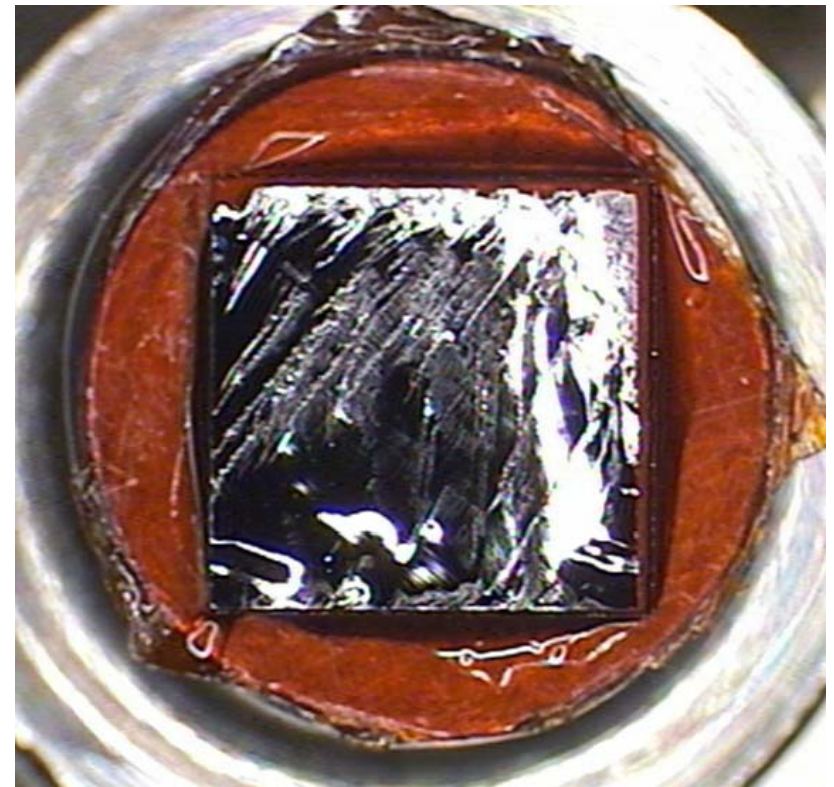
Silicon On Diamond Fabrication: **Improvements in 2011**

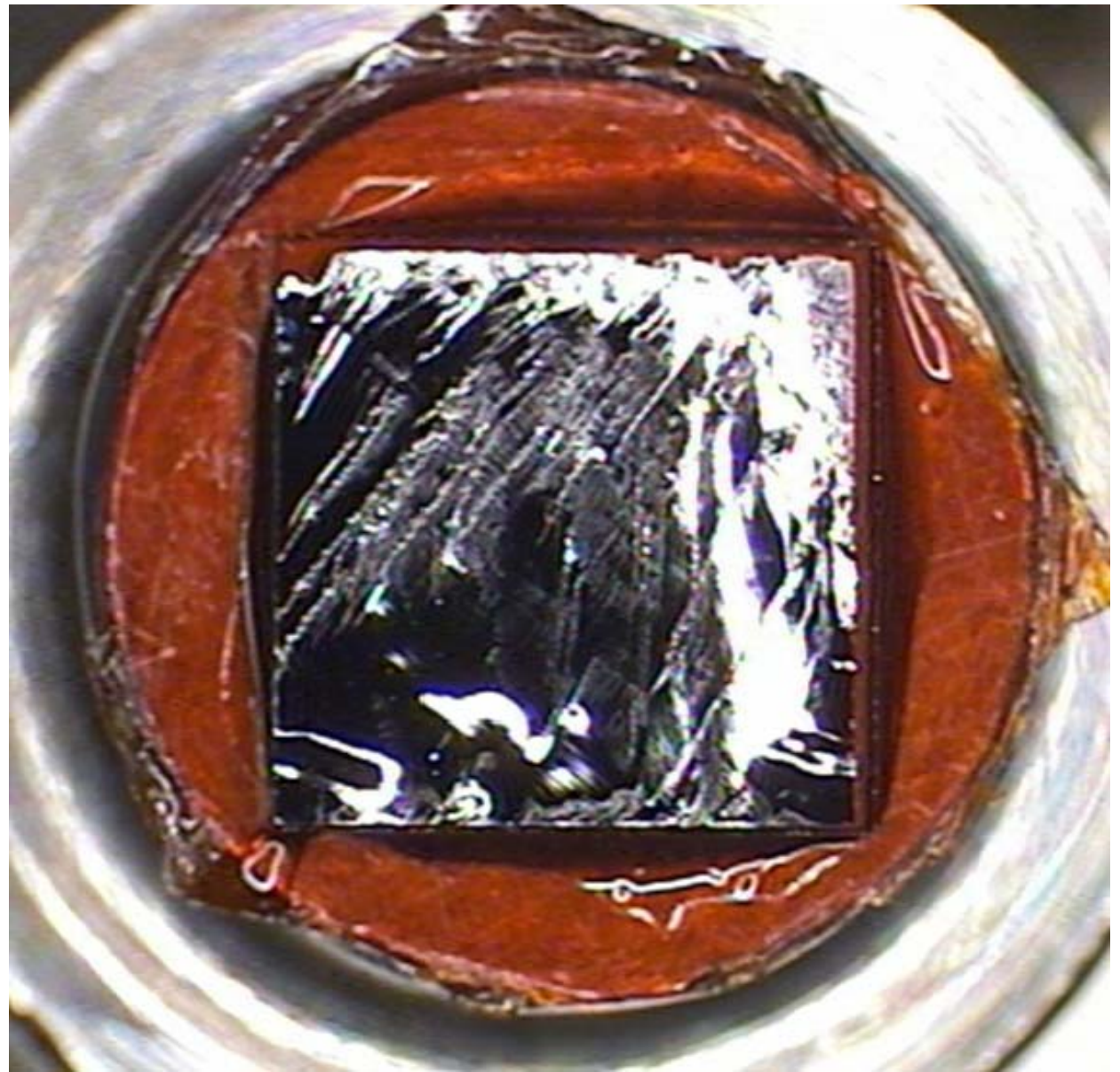
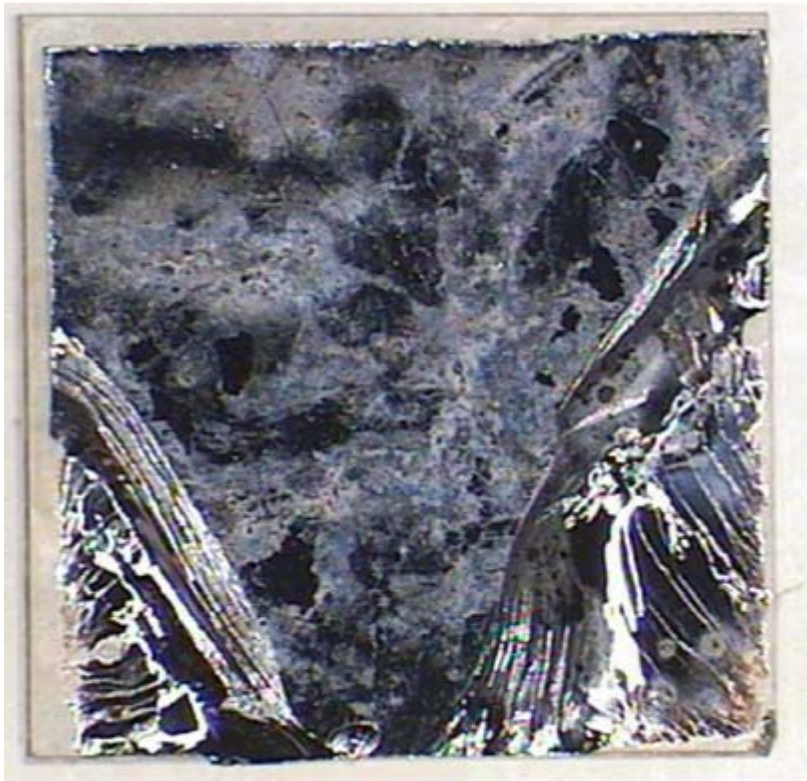


- Improved adhesion at tensile strength tests in samples bonded with lower energy density



FROM CARAT 2ND
TO 3RD MEETING

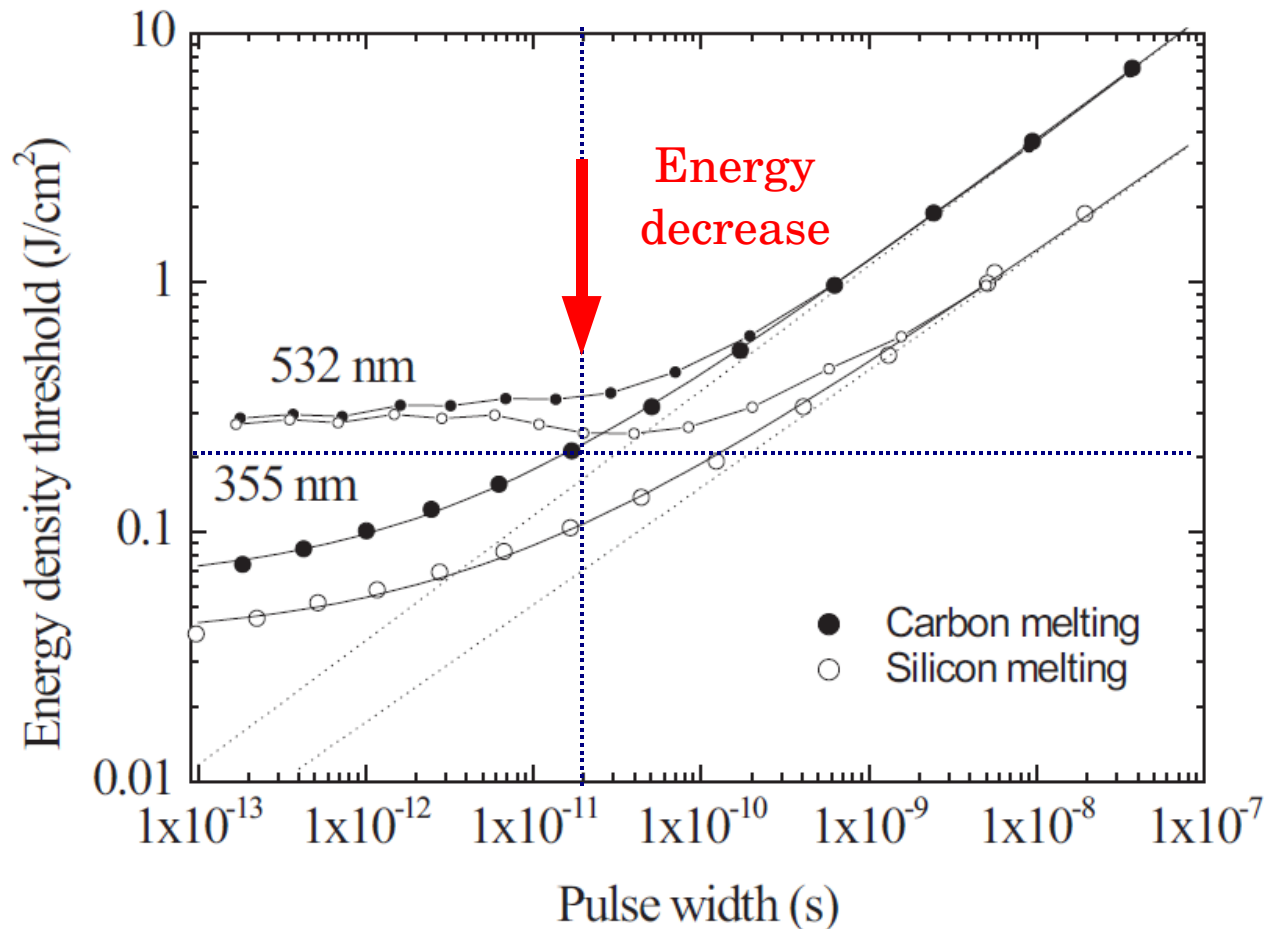




SOD22 & SOD 23

Silicon On Diamond Fabrication: Improvements in 2011

- Energy density used in the process decreased from 1-2 J/cm² to 0.5 J/cm²
Theoretical model*: 100 nm amorphous interface obtained with 1-2 J/cm² (measured by HRTEM)
- The interface decreases to 50 nm at the threshold of 0.2 J/cm²
- Further decrease by decreasing the wavelength and the pulse width



*Stefano Lagomarsino, Phenomenological model of Silicon-On-Diamond laser bonding, Diamond Relat Mater, Volume 20, Issue 7, July 2011, Pages 1010-1015

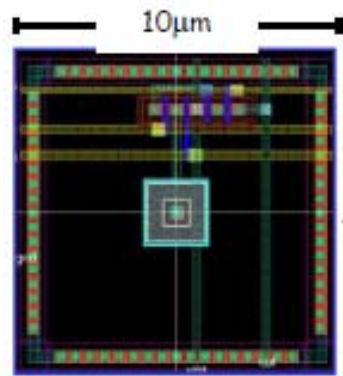
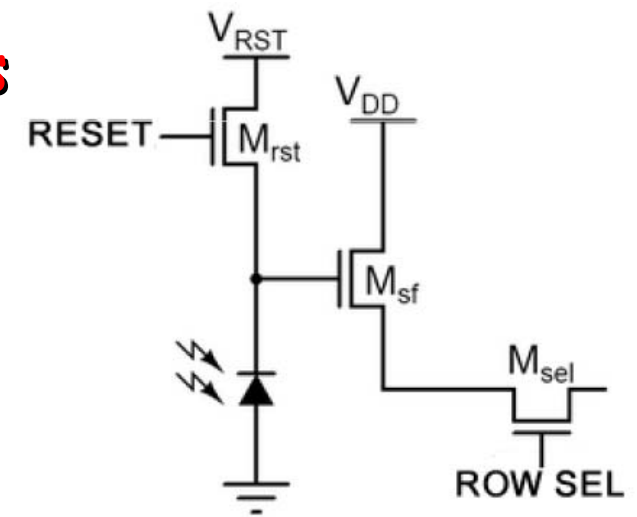
RAPS on DIAMOND: work in progress

GOAL:

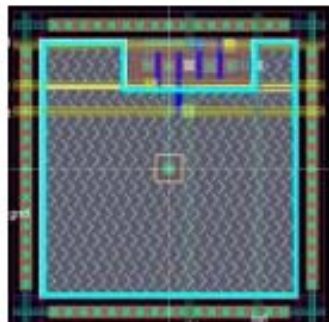
To test the functionality of a real chip

After \Rightarrow thinning (down to $40\text{ }\mu\text{m}$)

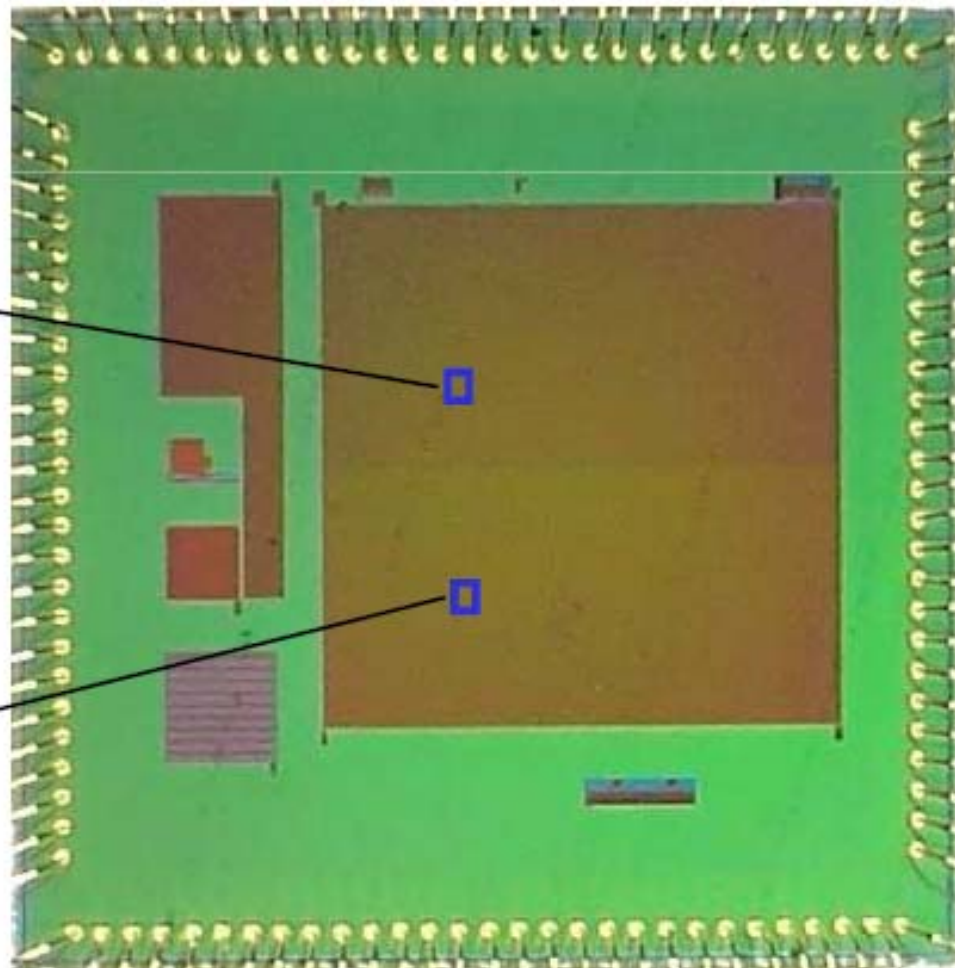
and \Rightarrow bonding to diamond



Small n-well, Low C



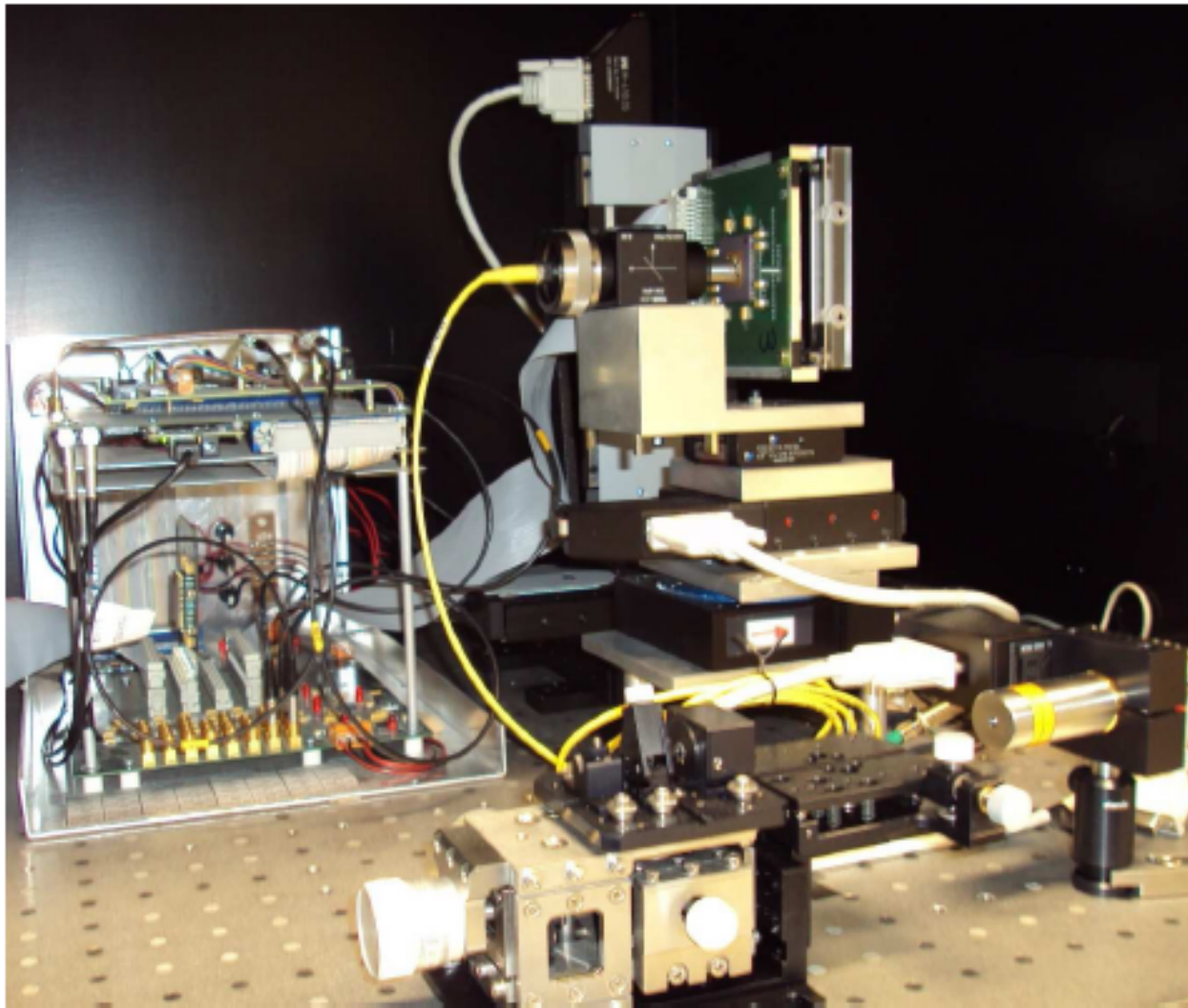
Large n-well, High FF



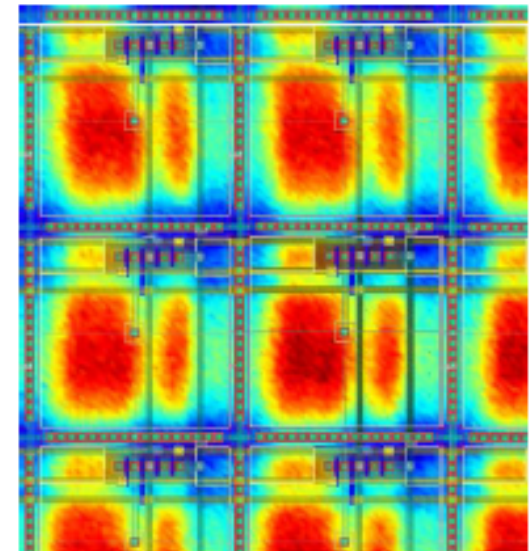
$\sim 5\text{mm}$

CMOS Active Pixel
Sensors
 256×256 matrix

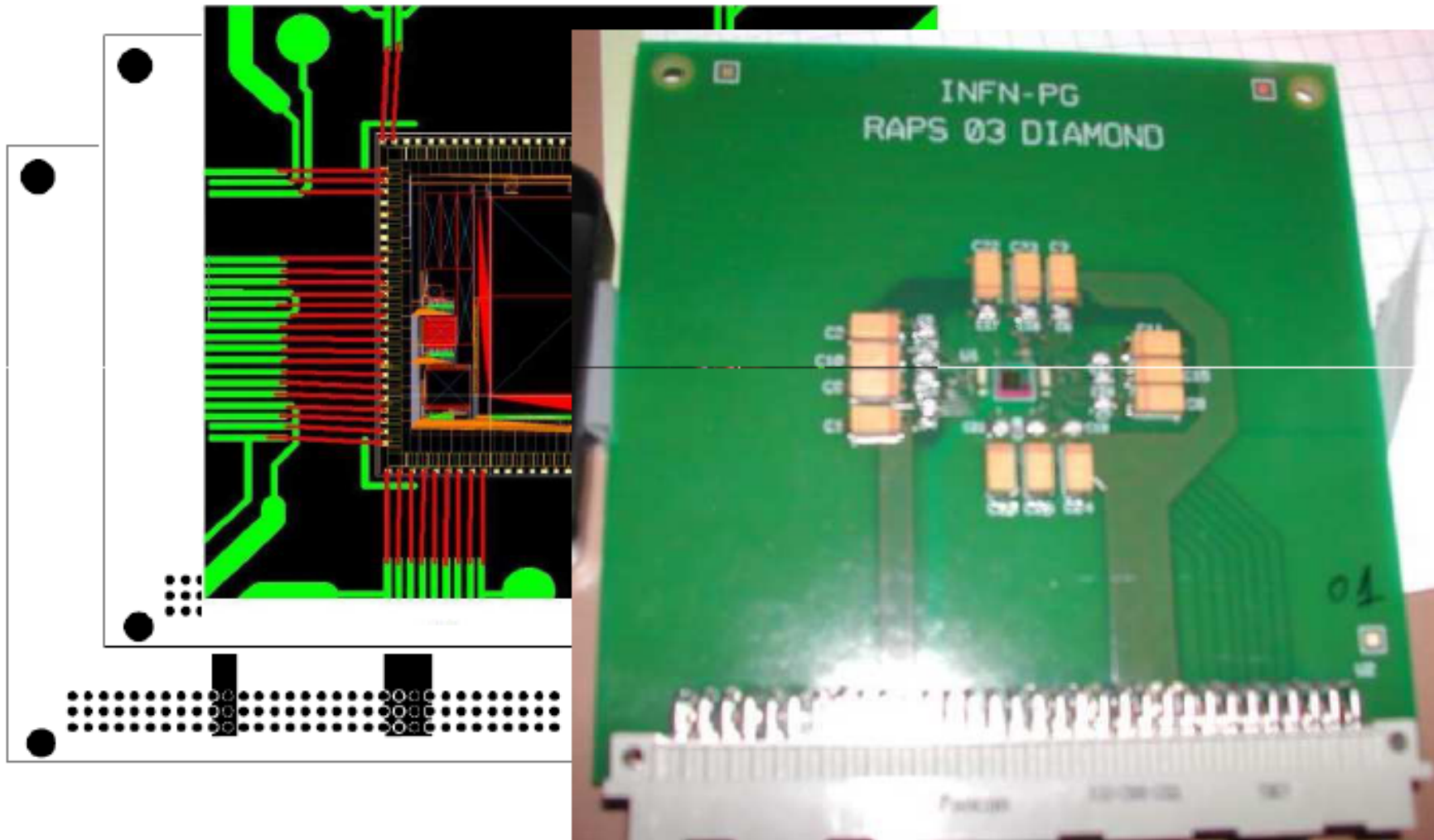
Test bench at INFN of Perugia Italy



- ✓ IR, UV, VIS laser with micro-focusing and positioning capabilities.
- ✓ Up to 4 sensors parallel read-out.
- ✓ Efficiency.
- ✓ Spatial resolution.
- ✓ Track reconstruction.



Test set up at INFN of Perugia Italy



Another relevant topic:
diamond graphitization, graphite diamond contact

Next Talk

Thank you for listening!