Nanoinnovation2020 – School on Nanotechnologies

Nano 2020 Innovation Conference & Exhibition Rome, 15-18 September

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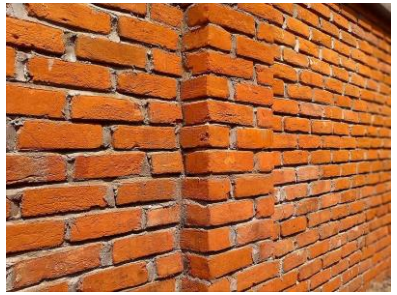
FONDAZIONE BRUNO KESSLER

MNF MICRO NANO FACILITY

It-fab Italian Network for Micro and Nano Fabrication



School on nanotechnologies: processes and applications to sensors and actuators

Basics
Welcome and introduction
Introduction to micro- and nano-fabrication
Deposition techniques (**PoliFAB**)
Litography (**Inphotec**)
Etching (**CNR BO**)
Direct Laser Writing (**INRIM**)

Basics
3D printing and two photon polymerization: toward the rapid prototyping of micro- nano- devices (**Chilab, Politecnico di Torino**)

Training Session
Building a silicon based actuator: theory and live demo from a cleanroom

Processes
Micro- Nano- devices for bio: How to develop a Lab on a chip and a biosensor (**Chilab, Politecnico di Torino**)

Processes
Photonics packaging: laser hybrid integration towards space applications (**Inphotec**)
High-density W-filled TSVs for advanced 3D-Integration (**Fraunhofer EMFT**)
System level 3D integration and system-in-package for chemical sensing microsystems (**CNR BO**)
Metrological approach to 3D SERS platform characterisation (**INRIM**)

Applications/devices, sensors, actuators
Ion-induced nanopatterning of semiconductor surfaces: a short link between basic research and applications (**FBK**)
QT/photonics devices; FET project with 3D integration for QT (**FBK**)
Materials, Sensors and Actuators in MEMS technology evolution (**ST**)
UV Sensor Technology Integrated on Unmanned Aerial Vehicle for Air Pollution Monitoring (**CNR LE**)
Superconducting Metamaterials for Microwave Photonics at the Single Photon Level (**INRIM**)
Flexible and large area electronics (**CNR RM**)

Single process steps

Technology modules

Applications of sensors and actuators

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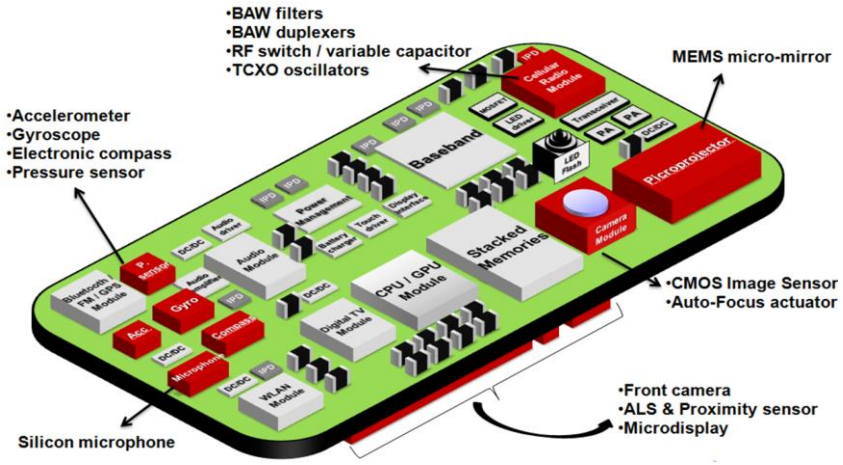
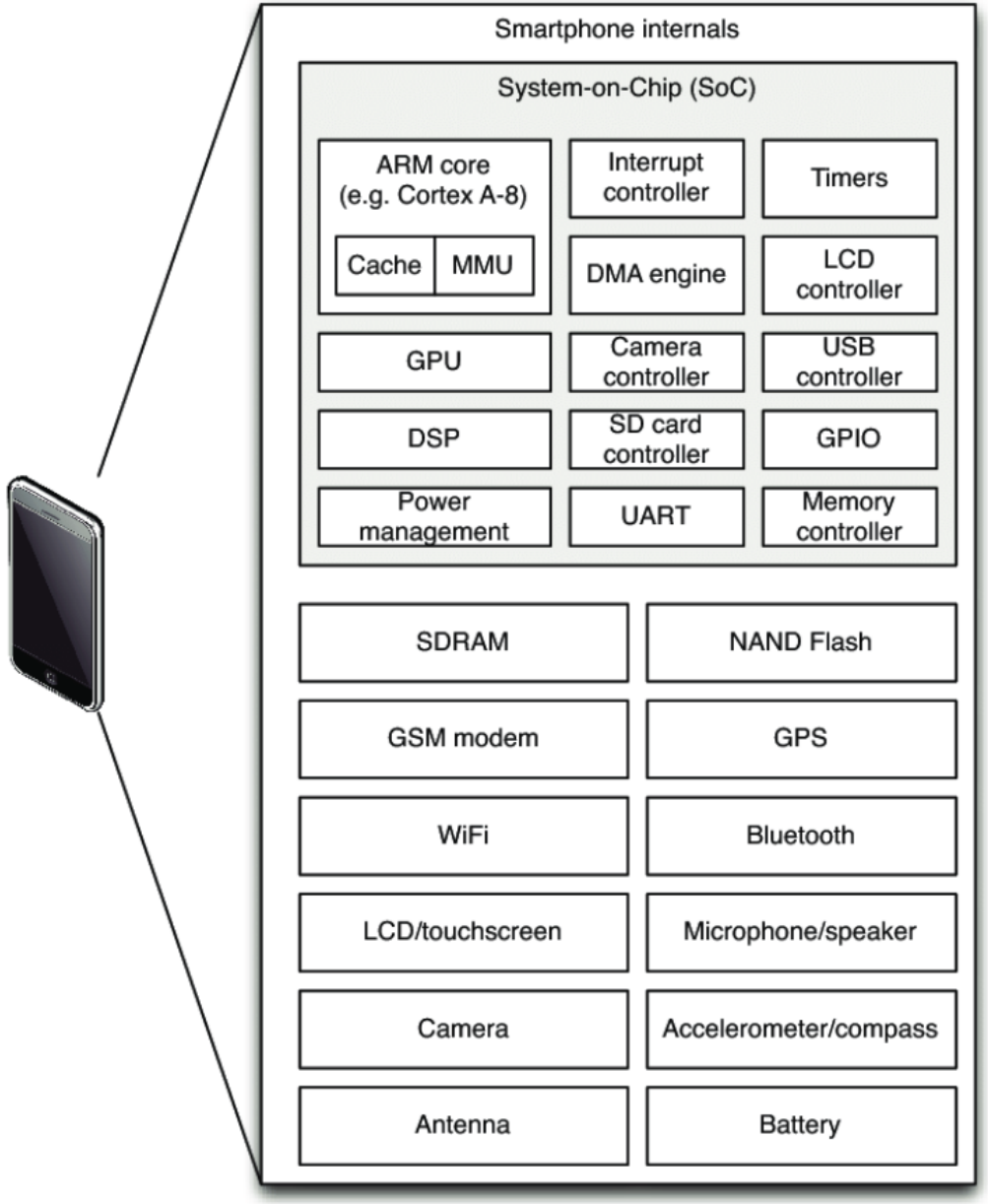
Microelectronic Devices, Sensors and Actuators: where they are

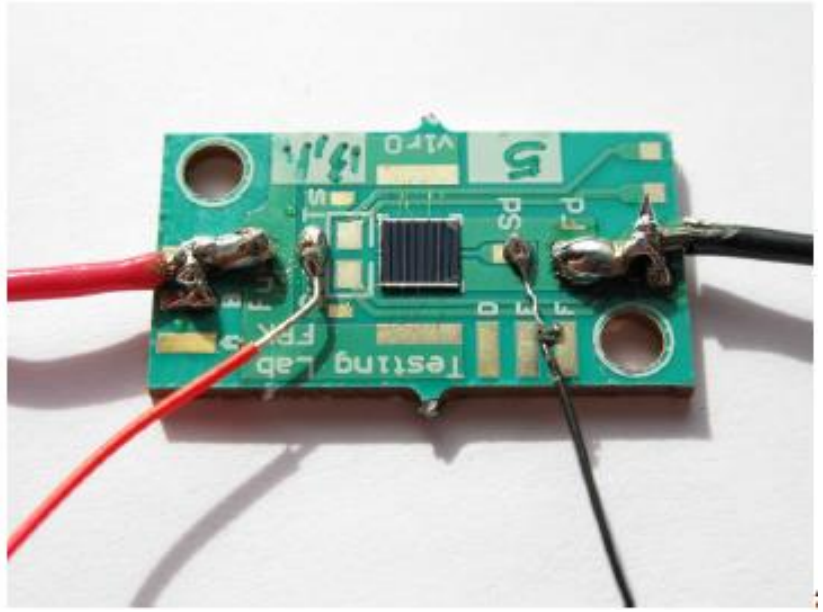


uploaded by Craig Newell, ResearchGate

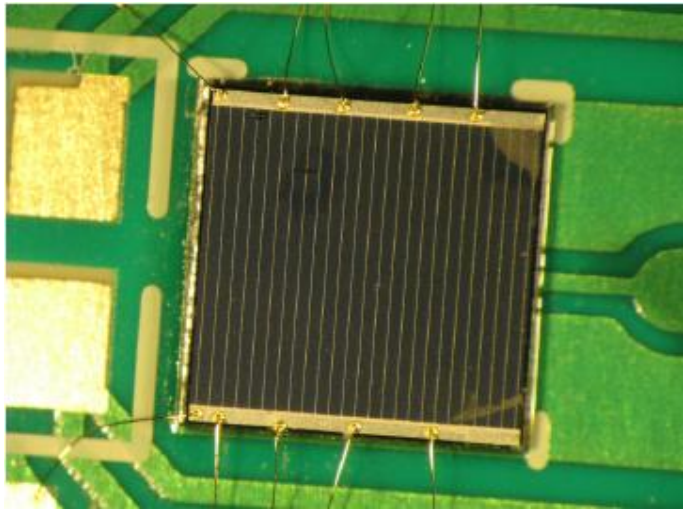


Microelectronic Devices, Sensors and Actuators: where they are

PV solar panel, concentration design – lenses on PV Si microcells

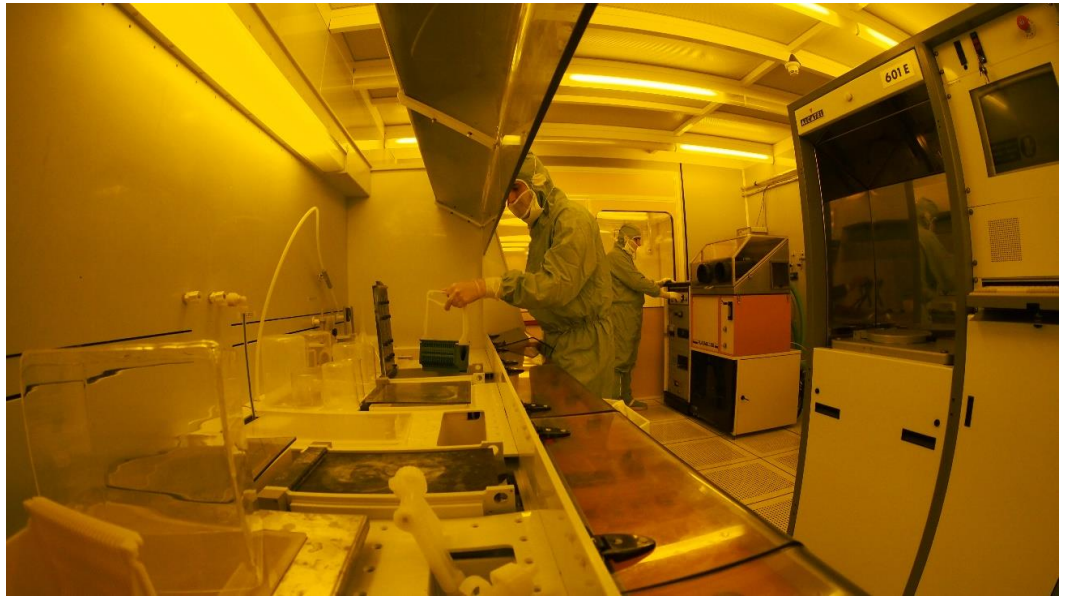


Single PV Si microcell mounted on test board

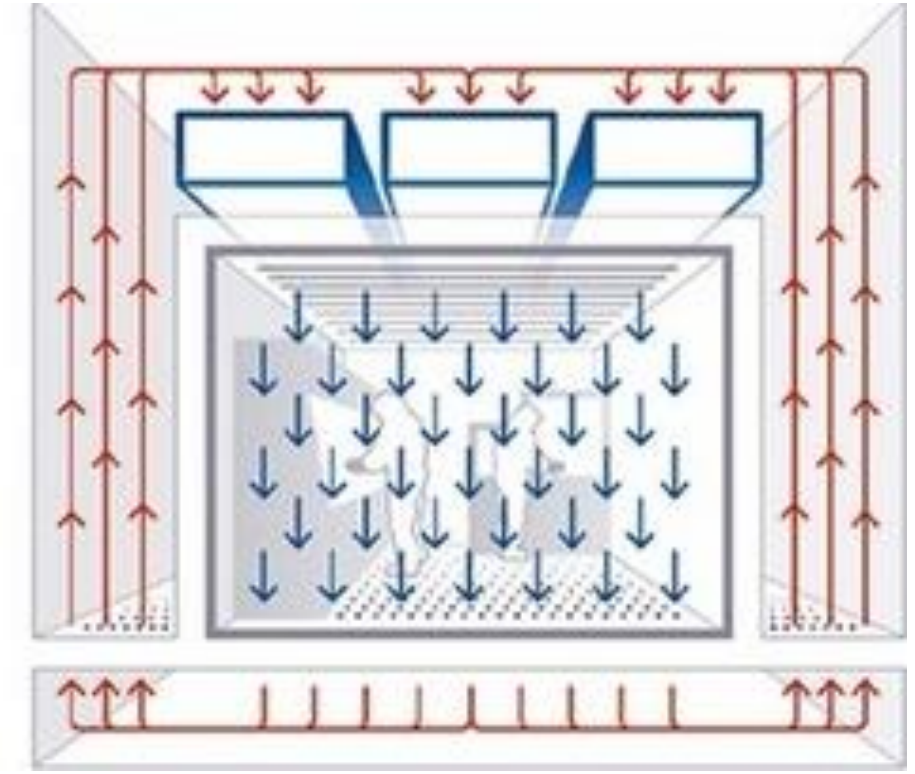


Silicon wafer with hundreds of cells

Where are semiconductor devices produced: the cleanrooms

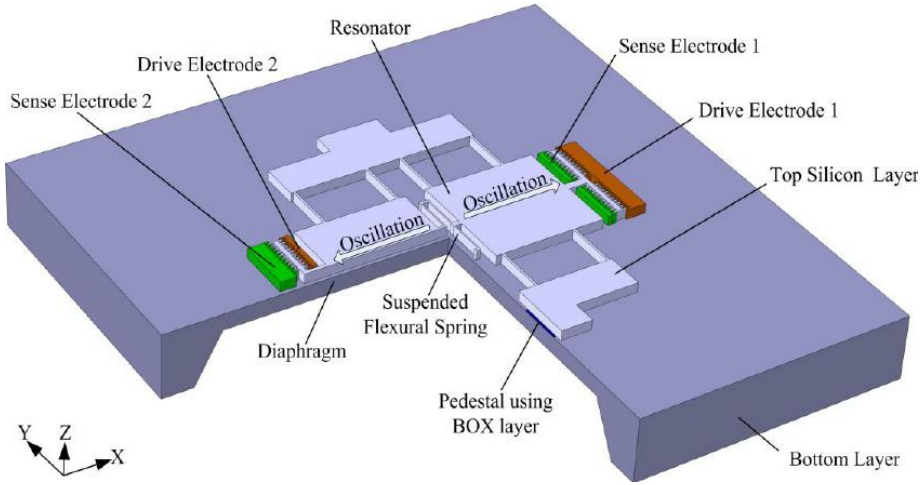


Cleanrooms have what you call laminar flow of ***clean*** air constantly flowing from the ceiling vertically downwards to the perforated raised flooring .

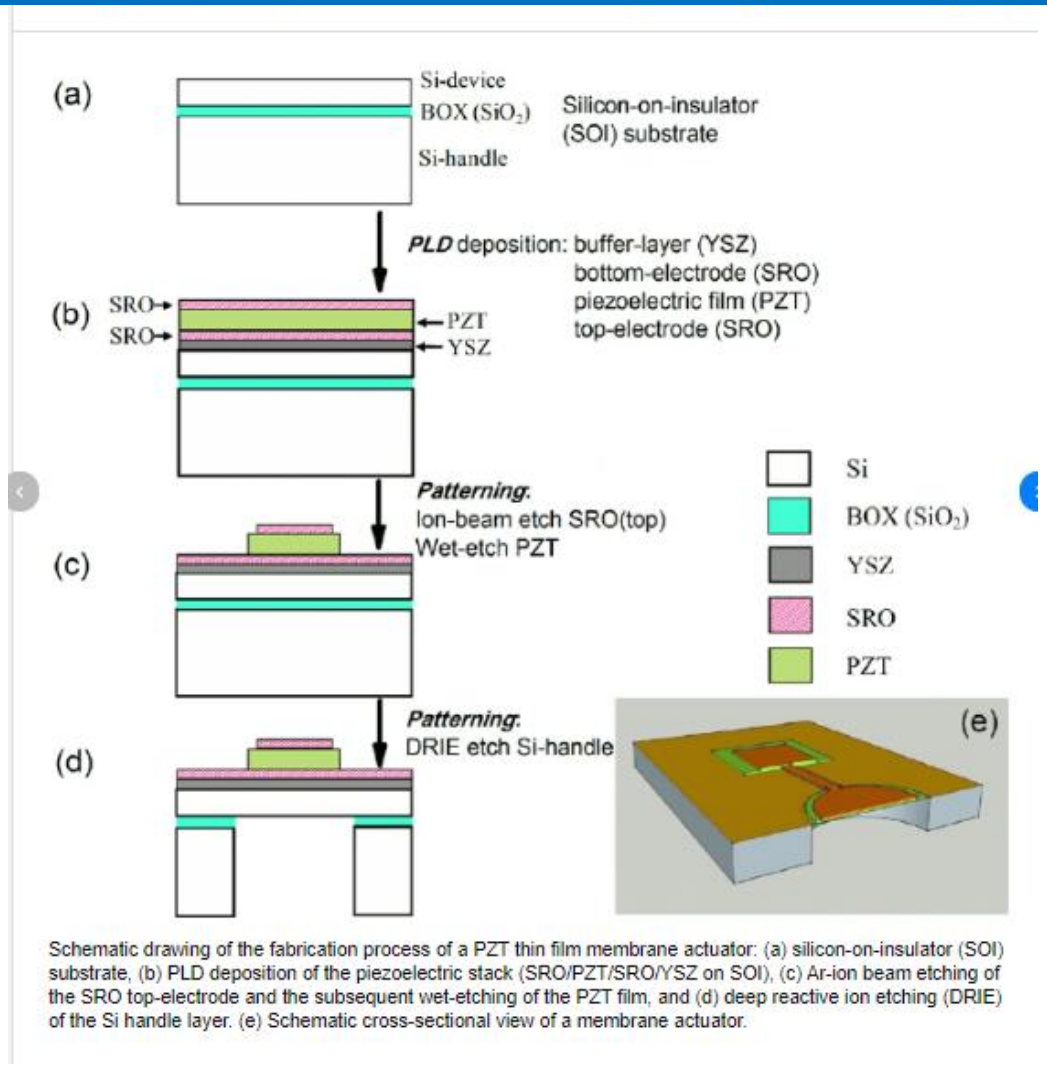


- ✓ Air is controlled in temperature and humidity
- ✓ Filters to clean air from dust and other particles
- ✓ Inside pressure higher than external

Resonant pressure sensor



DOI: 10.3390/s131217006
https://www.mdpi.com/1424-8220/13/12/17006



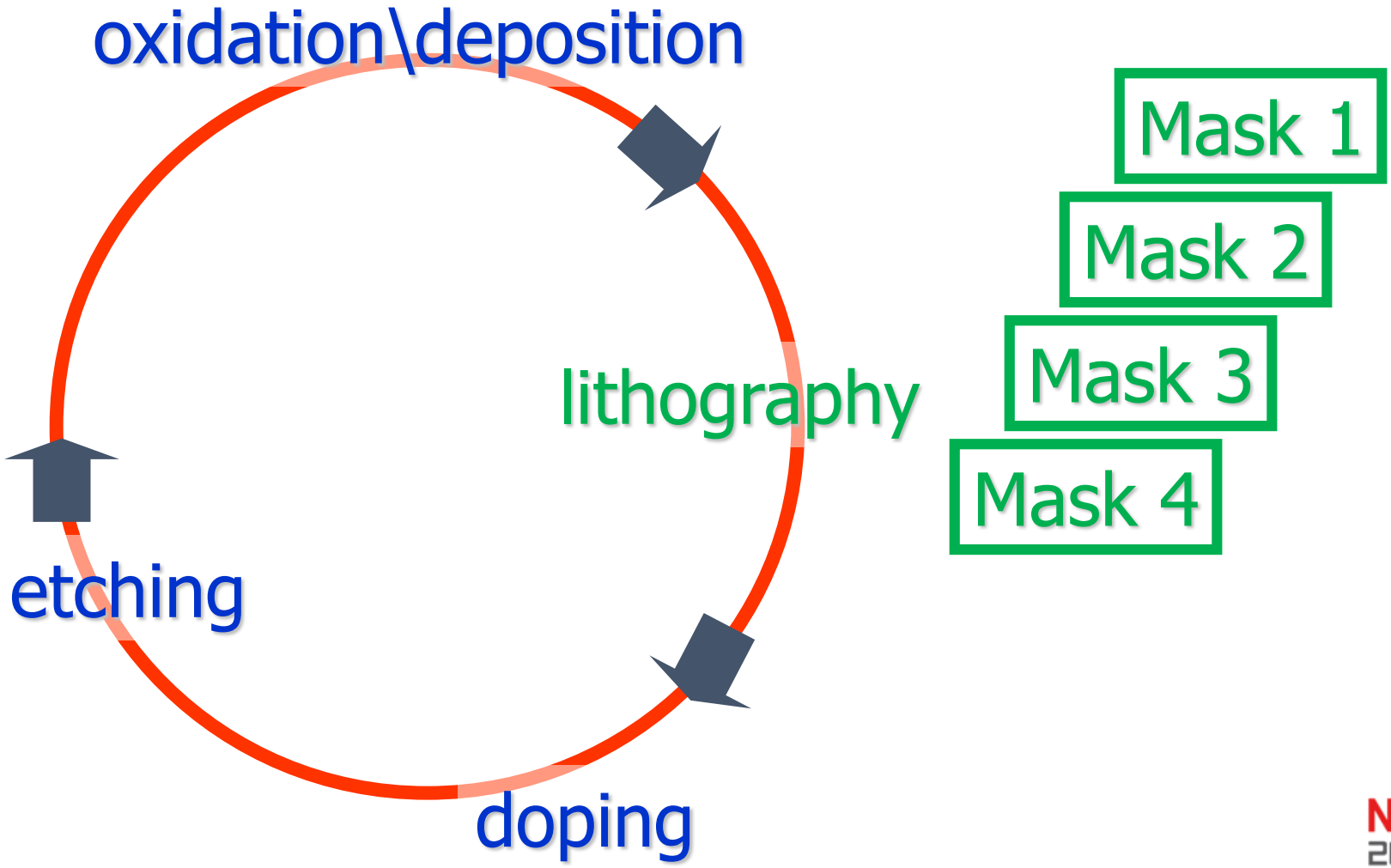
Schematic drawing of the fabrication process of a PZT thin film membrane actuator: (a) silicon-on-insulator (SOI) substrate, (b) PLD deposition of the piezoelectric stack (SRO/PZT/SRO/YSZ on SOI), (c) Ar-ion beam etching of the SRO top-electrode and the subsequent wet-etching of the PZT film, and (d) deep reactive ion etching (DRIE) of the Si handle layer. (e) Schematic cross-sectional view of a membrane actuator.

Nguyen, Minh & Nazeer, H. & Dekkers, J. & Blank, Dave & Rijnders, Guus. (2013). Optimized electrode coverage of membrane actuators based on epitaxial PZT thin films. Smart Materials and Structures. 22. 085013. 10.1088/0964-1726/22/8/085013.

Fabrication process

Sequence of addition and subtraction of thin layers of materials, according to precise and complex pattern transferred from a mask or a directly designed on the surface of the wafer

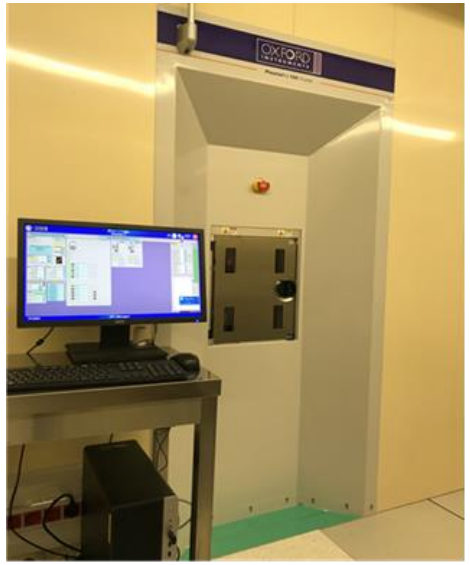
Each device structure a pattern level, a new material layer



Very common equipment in semiconductor cleanrooms

Thermal processes, deposition, doping

Etch – wet and dry



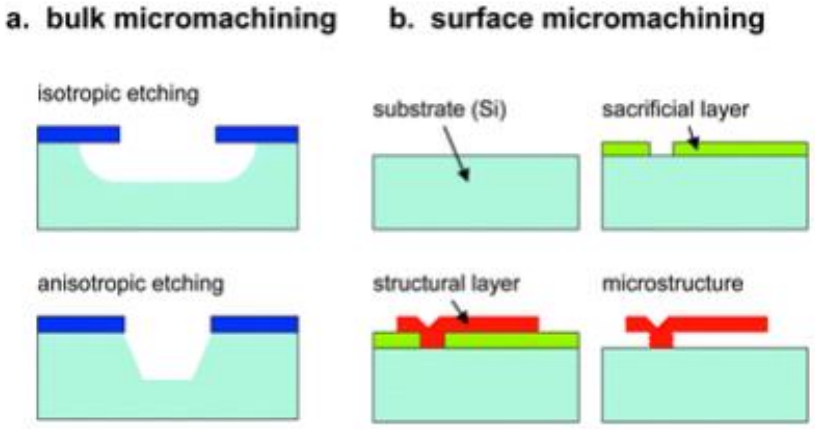
Doping

Thin filrm deposition - PECVD

Cleanroom equipment – front and back!

Surface and bulk micromachining

- Material deposition
- Stress reduction
- Bulk etching
- Sacrificial layer etching



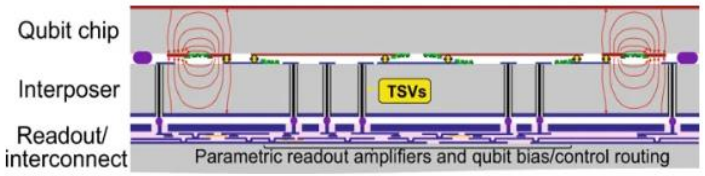
http://pubs.rsc.org/en/content/articlehtml/2003/AN/B208563C#sect274

3D integration

- Thinning of wafers – CMP and grinding
- Bonding – temporary or not
- TSV
- Isolation or conductive filling of TSV

Rosenberg, D., Kim, D., Das, R. *et al.* 3D integrated superconducting qubits. *npj Quantum Inf* **3,** 42 (2017). https://doi.org/10.1038/s41534-017-0044-0
MIT Lincoln Laboratory, 244 Wood Street, Lexington, MA, 02420, USA

Fig. 1



Envisioned scheme for control and readout of a large-scale, 3D integrated quantum processor. The qubit, interposer, and readout/interconnect chips are connected using indium bump bonds. The qubits are separated from the readout and control layer by an interposer chip with through-substrate vias that provide input/output (I/O) connectivity to/from the qubits. Because the chips are fabricated separately, each fabrication process can be optimized independently

- FBK developed a versatile SiPM/SPAD technology platform that could evolve in different specific technologies to cope with specific requirements

PET

NUV-HD SiPM → Near Ultra Violet Light detection (PDE >60% at 420nm)

Medical Imaging

RGB-HD SiPM → Visible Light detection (PDE >50% at 550 nm)

VUV-HD SiPM → Vacuum UV Light detection (PDE >25% at 175nm)

Lidar

NIR-HD SiPM → Near Infra Red Light detection (PDE = 20% at 850 nm)

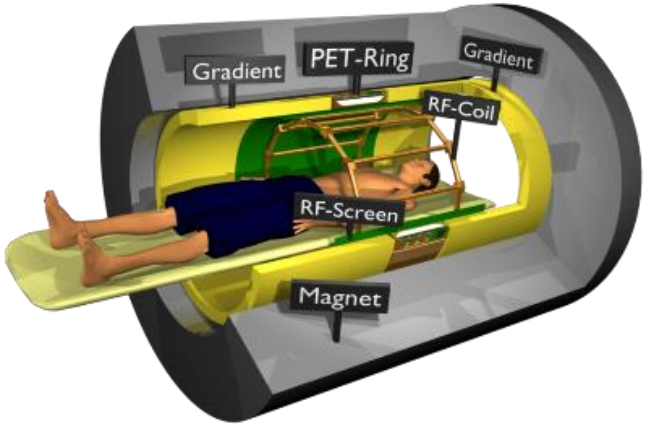
INFN – Darkside experiment

NUV-HD Cryo SiPM → Cryogenic applications

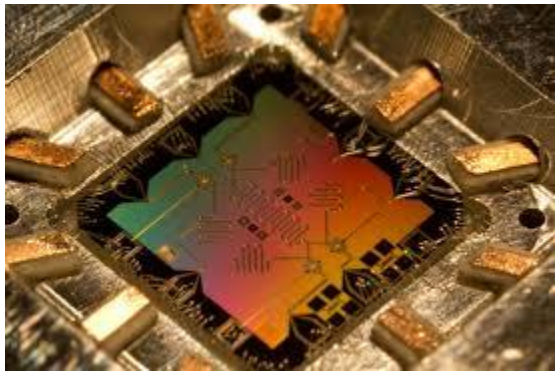
UHD-SiPM → Ultra High Density. High dynamic Range applications

SiPM – Silicon photomultiplier

BioMedical instrumentation

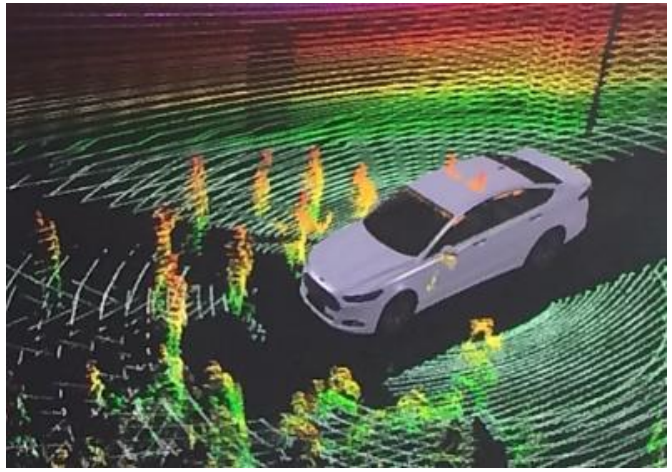


Quantum Technology and Computing

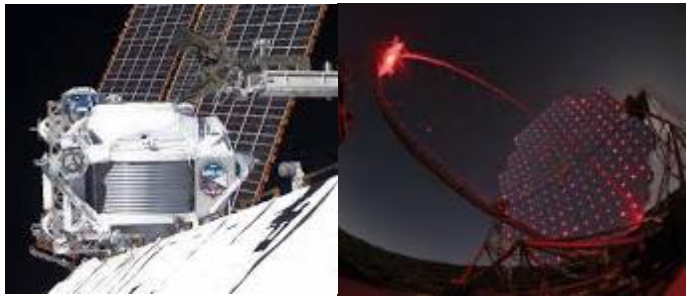


Industrial instrumentation

Automotive



Space and astrophysics



High energy physics

Thanks for the attention!

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