Nanoinnovation2020 – School on Nanotechnologies

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It-fab Italian Network for Micro and Nano Fabrication
| Basics | Welcome and introduction  
Introduction to micro- and nano-fabrication  
Deposition techniques (PoliFAB)  
Litography (Inphotec)  
Etching (CNR BO)  
Direct Laser Writing (INRIM) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Session</td>
</tr>
<tr>
<td>Processes</td>
</tr>
</tbody>
</table>
| 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)  
QF/photonic devices; FET project with 3D integration for QT (FBK)  
Materials, Sensors and Actuators in MEMS technology evolution (ST)  
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) |
Microelectronic Devices, Sensors and Actuators: where they are
Silicon wafer with hundreds of cells

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

Single PV Si microcell mounted on test board
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
Silicon sensors and actuators – how are they built

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.
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 film deposition - PECVD
Cleanroom equipment – front and back!
Process modules

Surface and bulk micromachining
- Material deposition
- Stress reduction
- Bulk etching
- Sacrificial layer etching

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

3D integration
- Thinning of wafers – CMP and grinding
- Bonding – temporary or not
- TSV
- Isolation or conductive filling of TSV

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:

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

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

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

- **NIR-HD SiPM**
  - INFN – Darkside experiment
  - Near Infra Red Light detection (PDE = 20% at 850 nm)

- **NUV-HD Cryo SiPM**
  - Cryogenic applications

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

PET

Medical Imaging

PET

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SiPM – Silicon photomultiplier

Applications

- BioMedical instrumentation
- Quantum Technology and Computing
- Industrial instrumentation
- Automotive
- Space and astrophysics
- High energy physics
Thanks for the attention!
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