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Semi-Disposable Biochips in CMOS Technology

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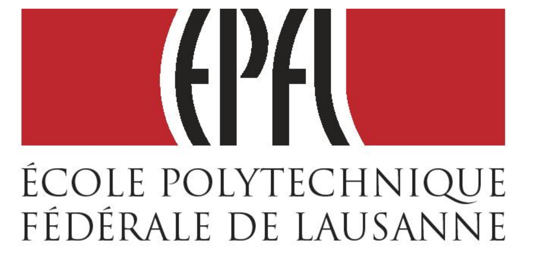
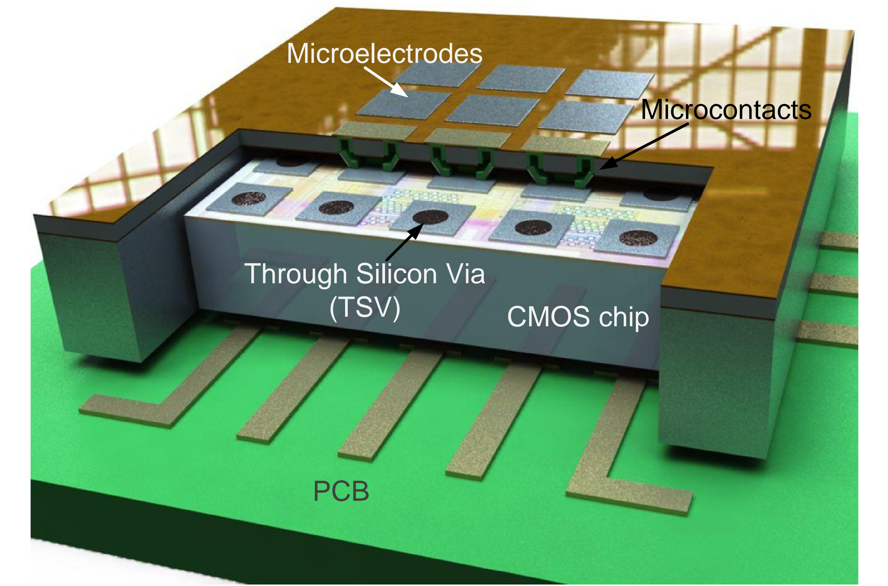
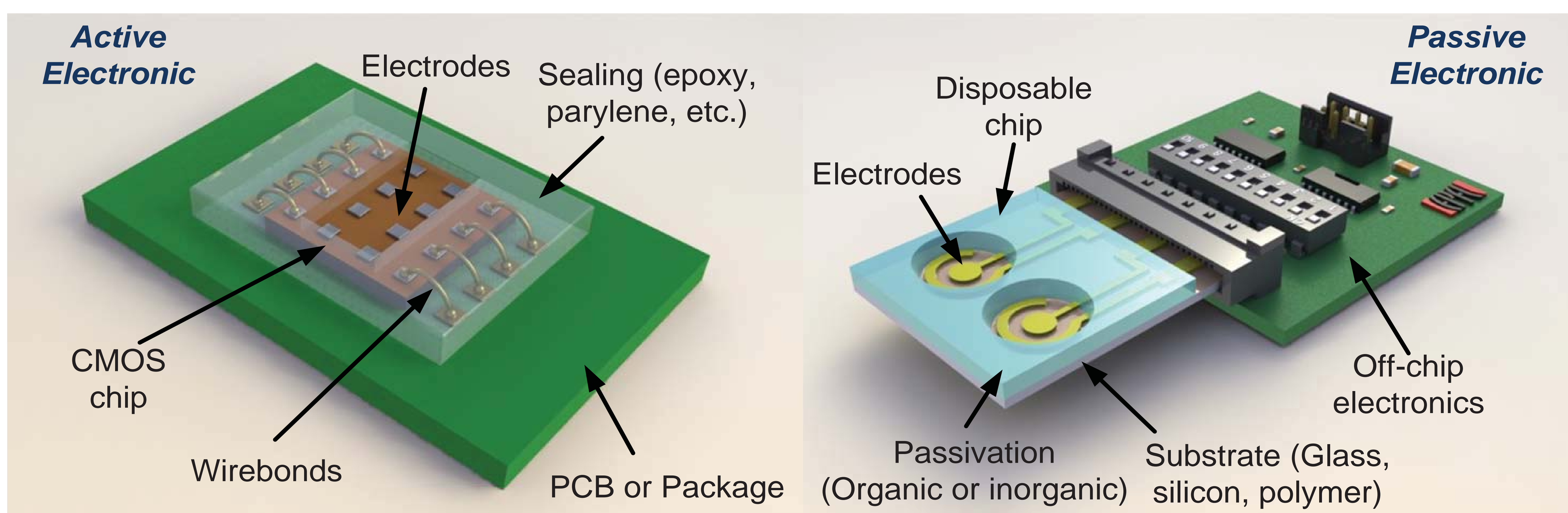


INTRODUCTION

This work adds a new dimension to the integrated circuits technology for lab-on-a-chip systems by employing 3D integration technology for improved performance and functionality. One key issue for the commercialization of fully integrated systems for personalized medicine applications is the disposability of the assay-substrate at a low cost. In this sense, it is proposed that a disposable biosensing layer can be aligned and temporarily attached to the 3D CMOS stack by the vertical interconnections, and can be replaced after each measurement. This approach combines the advantages of active-electronic and passive-electronic biochips in one system, and fully decouples the CMOS and biosensor fabrications.



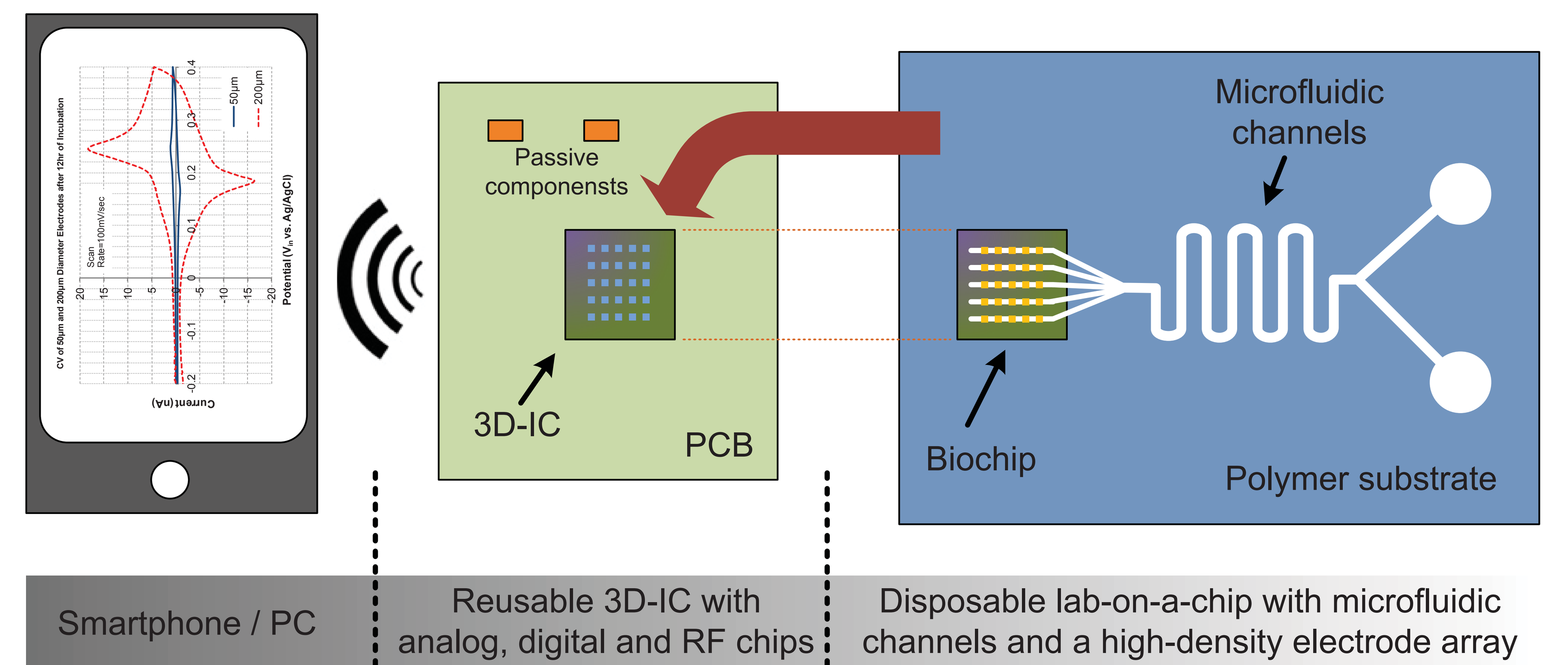
Active- and Passive-Electronics Biosensors



	PASSIVE	ACTIVE
Density	Low	✓Medium-High
Cost	✓ Low	High
Disposable	✓ Yes	No
Performance	Low	✓High

In passive chips, the electrode array density and the overall performance are limited due to long interconnections between the sensing sites and the electronics. Active biosensors enable superior electrical performance and higher array densities, however, they are not disposable. *(Y. Temiz et al., Electronics Letters, 2011)*

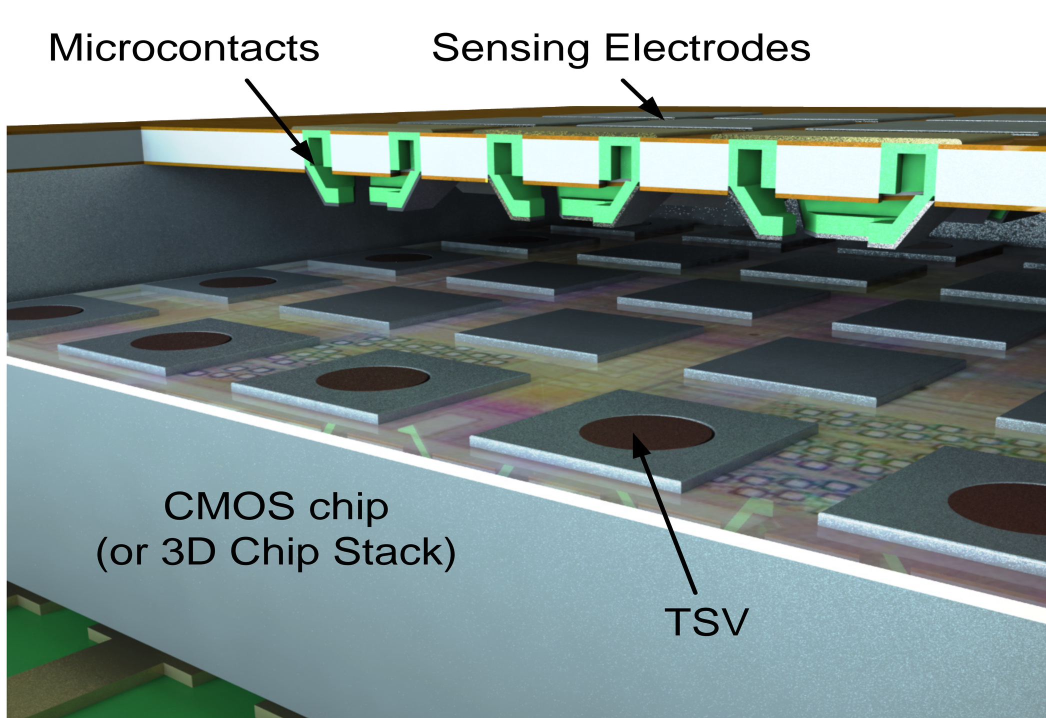
3D Integrated Biosensing System

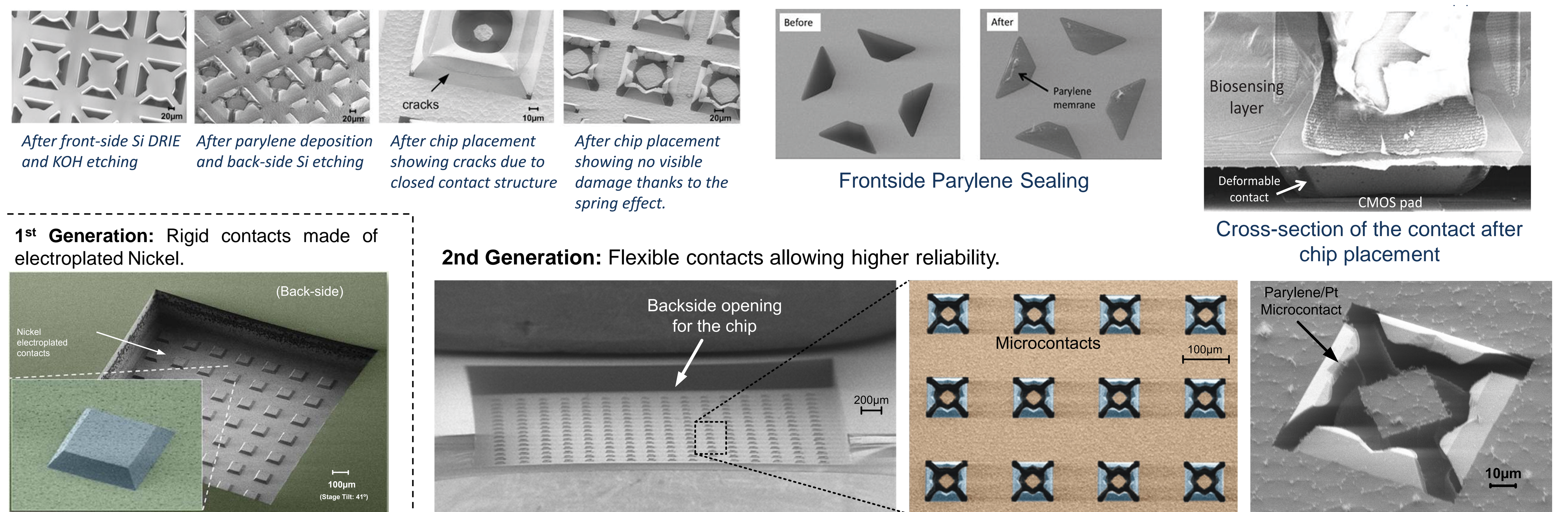


The system is composed of a vertically stacked 3D chip mounted on a PCB, and a disposable cartridge with microfluidic channels and a biochip with vertical interconnections. The contacts on the biochip enable a reliable connection between the high-density electrodes and the 3D chip. After each measurement, the low-cost cartridge is disposed and the 3D-IC is reused. The wireless communication can be achieved and the results can be displayed on a PC or a smartphone.

Flexible Microcontact Fabrication

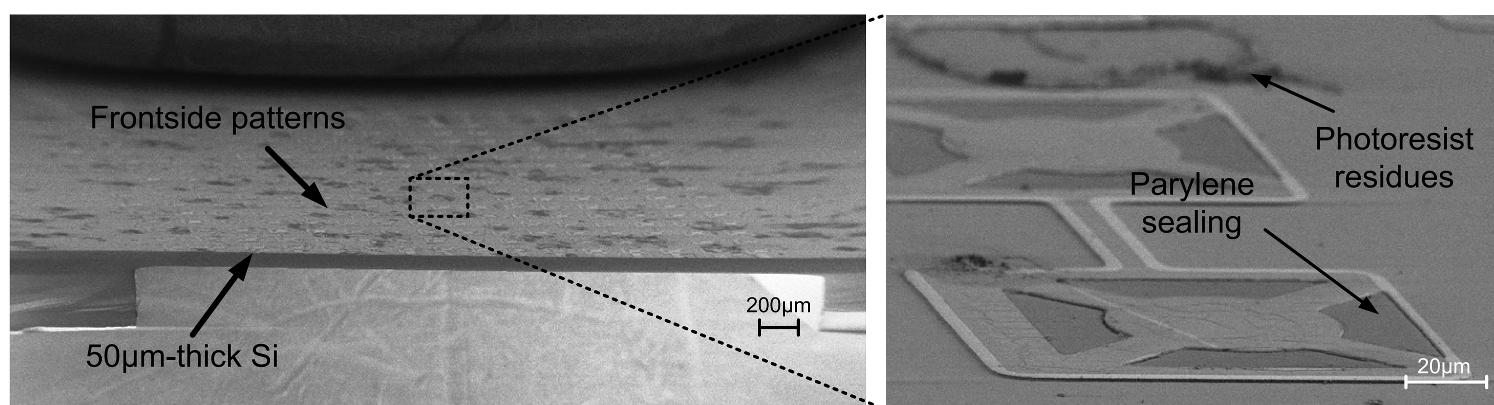
Silicon wafer is etched by DRIE followed by KOH. A metal film is deposited through the openings for the electrodes and the contacts. After etching the Si backside, parylene is deposited to form the springs and to seal the frontside openings.



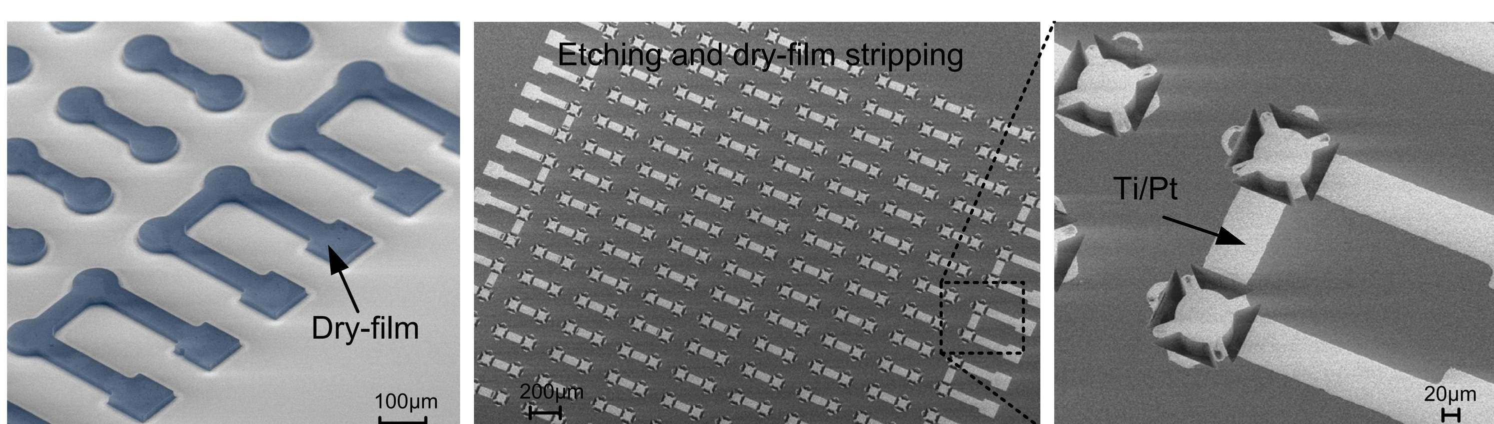


Frontside Microelectrode Patterning

- Parylene Sealing → Standard photolithography → Etching



- Dry-film lithography on very high topography → Etching or lift-off

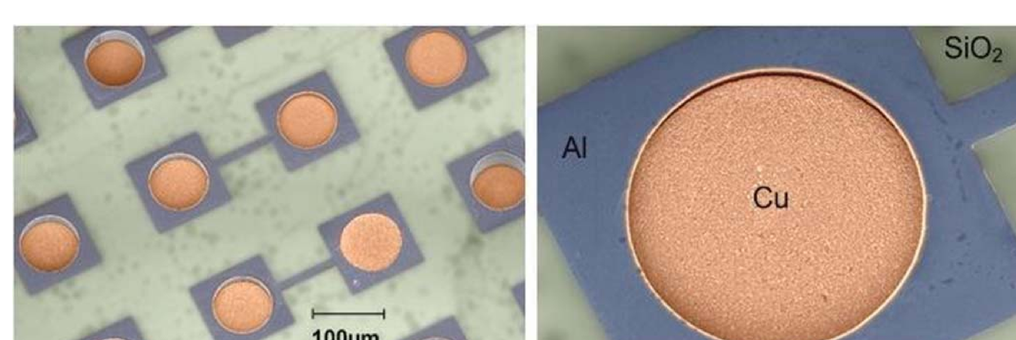


Chip-Level TSV Fabrication

Wafer reconstitution and die-level post-processing techniques which enable CMOS-compatible TSV fabrication and chip-to-chip integration.

- TSV technology for I/O pads (parylene sidewall passivation, bottom-up Cu electroplating). *(Y. Temiz et al., Transducers'11)*
- TSV technology for chip-to-chip integration (parylene bonding and sidewall passivation, Cu electroplating with seed layer). *(Y. Temiz et al., ECTC'12)*

Through-Silicon-Via (TSV) Fabrication for I/O Pads



Disposable Biochip

The fabricated biochip is composed of 256 microelectrodes and flexible microcontacts.

Video shows the preliminary measurements when the biochip is aligned and placed on a dummy Si chip.