3D ICs and pixel sensors: the Italian VIPIX project and the European AIDA WP3 project

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The Italian VIPIX project (Vertically Integrated PIXels)

- 8 labs participating in this program supported by INFN (Italian Institute for Nuclear Physics):
  - Bologna, Pisa, Perugia, Pavia-Bergamo, Roma3, Milano, Trento, Trieste

- Vertically integrated pixel detectors have the potential to satisfy the needs of the next generation of high energy physics experiments (main interest of VIPIX groups: Super B-Factory):
  - small pitch pixels capable of handling high data rates.
  - complex functionalities at the pixel level (low-noise amplification, zero suppression, time stamping...)

- The Tezzaron/GlobalFoundries technology appears to be very interesting for the fabrication of three-dimensional microelectronic circuits:
  - monolithic active pixel sensors
  - mixed-signal integrated circuits for the readout of high-resistivity fully-depleted silicon pixel sensors.
VIPIX concepts for 2-tier devices in the Tezzaron/GlobalFoundries process

Convert 2D MAPS device to a full CMOS 3D design, with digital readout separated from the sensor and the analog front-end

3D MAPS

3D mixed-signal readout integrated circuits

Interconnection between a 3D CMOS readout electronics chip and a fully-depleted high resistivity sensor, possibly with a low-mass, low-pitch technology.
INFIN-VIPIX in the first 3D-IC Consortium MPW run in the Tezzaron vertical integration technology

In late 2008 VIPIX joined other international laboratories and universities with interest in High Energy Physics in a consortium for the development of 3D integrated circuits, hosted by Fermilab; first MPW submission in 2009.

Symmetry line

One set of masks for both bottom and top tier to reduce cost, identical wafers bonded face-to-face.

VIPIX structures in this MPW run:

✓ **Subreticule E** - 7 sub-circuit areas, 3D MAPS test structures

✓ **Subreticule F** - 3D MAPS, large matrix
  ✓ 3D MAPS device with 256 x 240 array of 20 um pitch pixels
VIPIX plans and expectations with respect to the 3D Tezzaron/GlobalFoundries technology

• VIPIX is already progressing in the design work for a new MPW run (1Q–2Q 2011) in the 3D Tezzaron/GlobalFoundries process.

Two main devices will be included by VIPIX in the 2011 run:
  • A 3D deep N-well active pixel sensor: 100x128, 50 μm pitch with high rate sparsified readout architecture
  • a 3D readout chip for high resistivity pixel sensors (similar architecture): 128x32, 50 μm pitch

• We believe 3D vertical integration technology provides exciting opportunities and have the potential for a performance breakthrough with respect to present pixel sensors for particle detection

• Access to MPW and engineering runs is crucial to us, along with the availability of 3D design tools (it should be like standard CMOS)

• We need to gain experience with a 3D technology, with design rules and process features not changing too fast, and eventually get working devices for actual applications
AIDA WP3: Microelectronics and interconnection technology

• The AIDA project responds to the FP7-INFRASTRUCTURES-2010-1 call from the European Commission. AIDA addresses infrastructures required for the development of detectors for future particle physics experiments.

• The AIDA proposal was successfully granted EU funding. The project will begin in 2011 and will run for 4 years.

Task 3.2: 3D Interconnection; coordinators H.-G. Moser (MPI-Munich), V. Re (INFN)

• Several European institutions AGH-UST, CERN, CEA, MPI and UBONN, INFN, CNRS (CPPM and IPHC), STFC, CSIC (UB), SWEDET

• Organisation of a network of contacts with industry to enable fabrication of silicon sensors and electronics optimized for 3D interconnection

• Assess 3D vertical integration techniques enabling the High Energy Physics community to advance the state of the art of particle detectors

• MPW runs with the Tezzaron/GlobalFoundries Technology are being evaluated as a possible source of 3D CMOS readout chips, to be connected to sensors by a vertical integration process to be selected.