Tezzaron SEMICONDUCTOR

S3S Conference
2.5/3D Technology and Commercialization

October 11, 2016

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WHAT ARE THE DRIVERS OF CHANGE?

Precipitating Events for Change

FALLOUT FROM A FIRE: CHIP PRICES SOAR

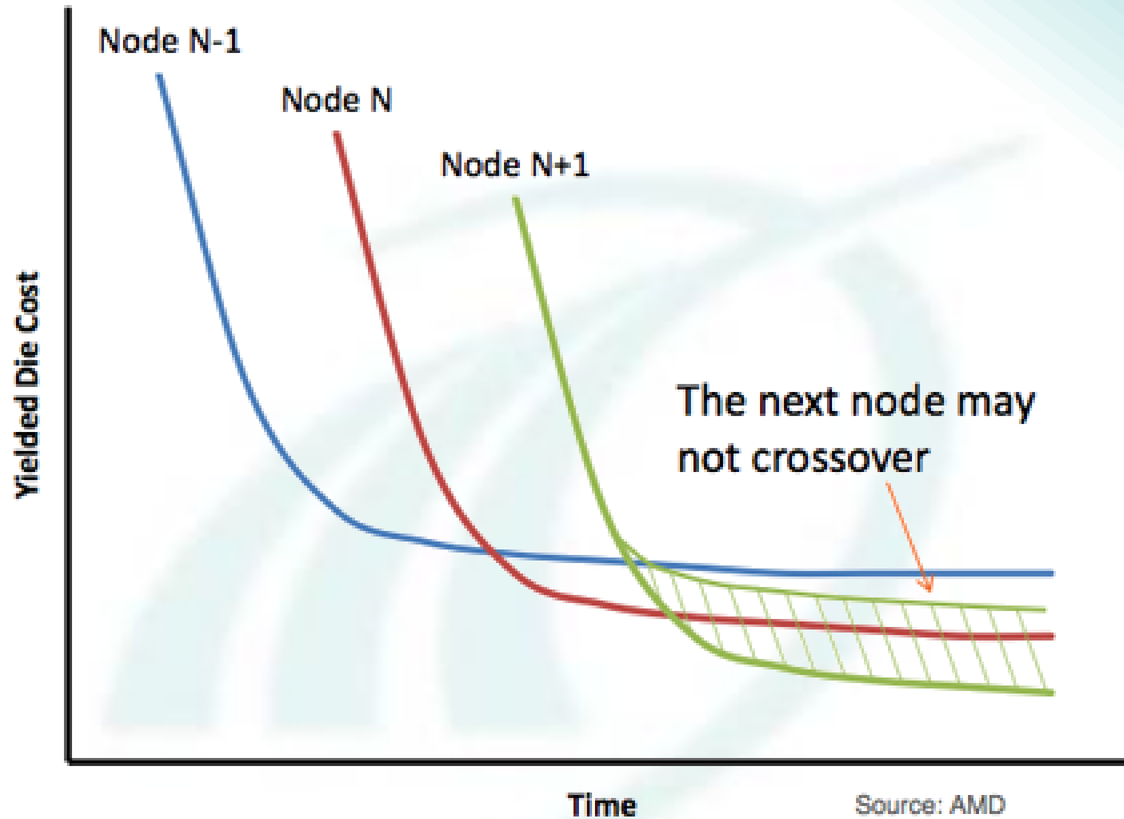
The Washington Post

By John Mintz July 22, 1993

Prices on some computer memory chips have almost doubled in recent weeks, and one reason is an explosion at a Japanese plastics factory that makes a compound used in the chips. But some computer industry executives say the prices probably will drop as fast as they rose once alternative sources for the plastic are found.

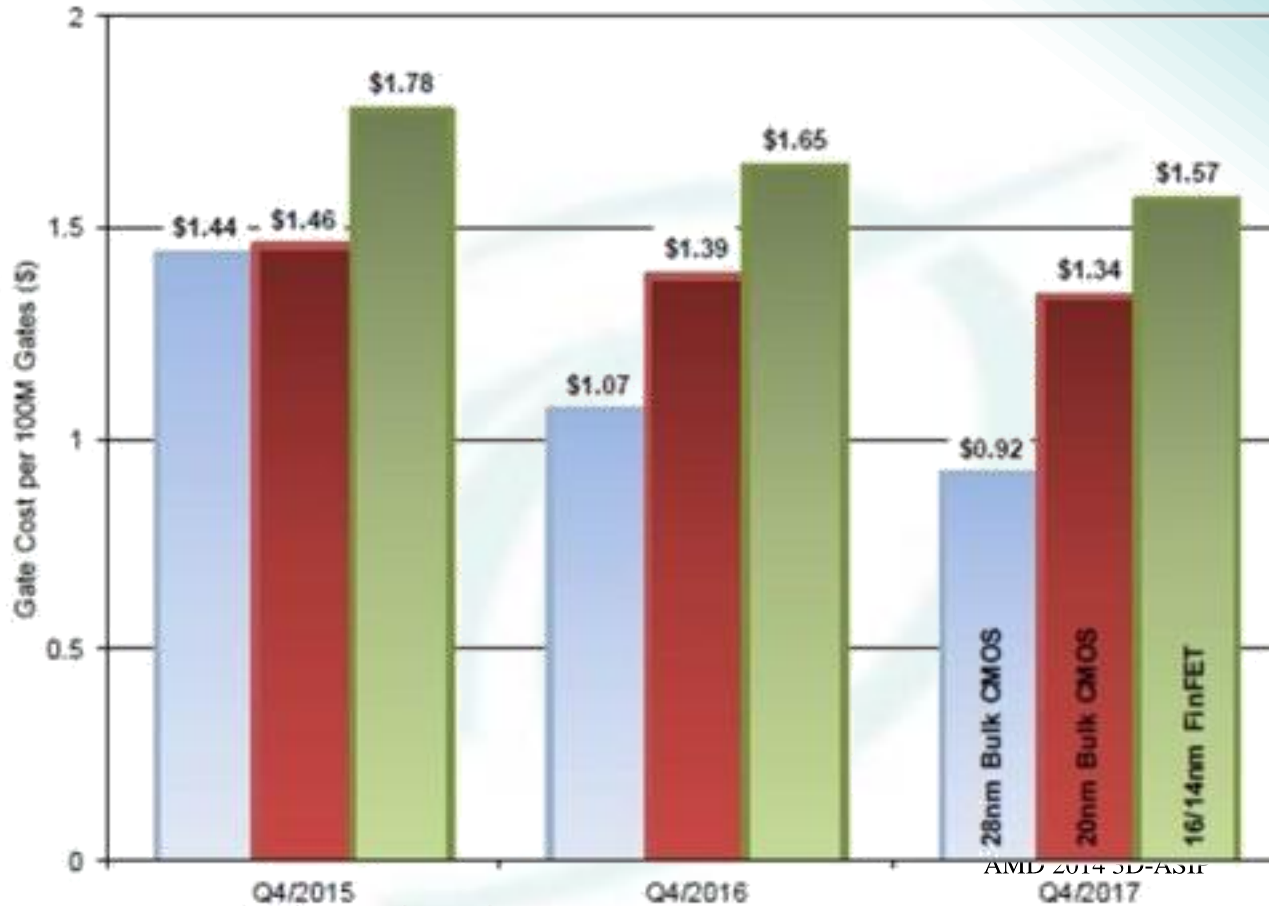
The July 4 fire destroyed the Sumitomo Chemical Co. plant in Nihama, which supplies 60 percent of the epoxy resin used to manufacture DRAM -- dynamic random access memory -- computer chips.

Expiring Economics



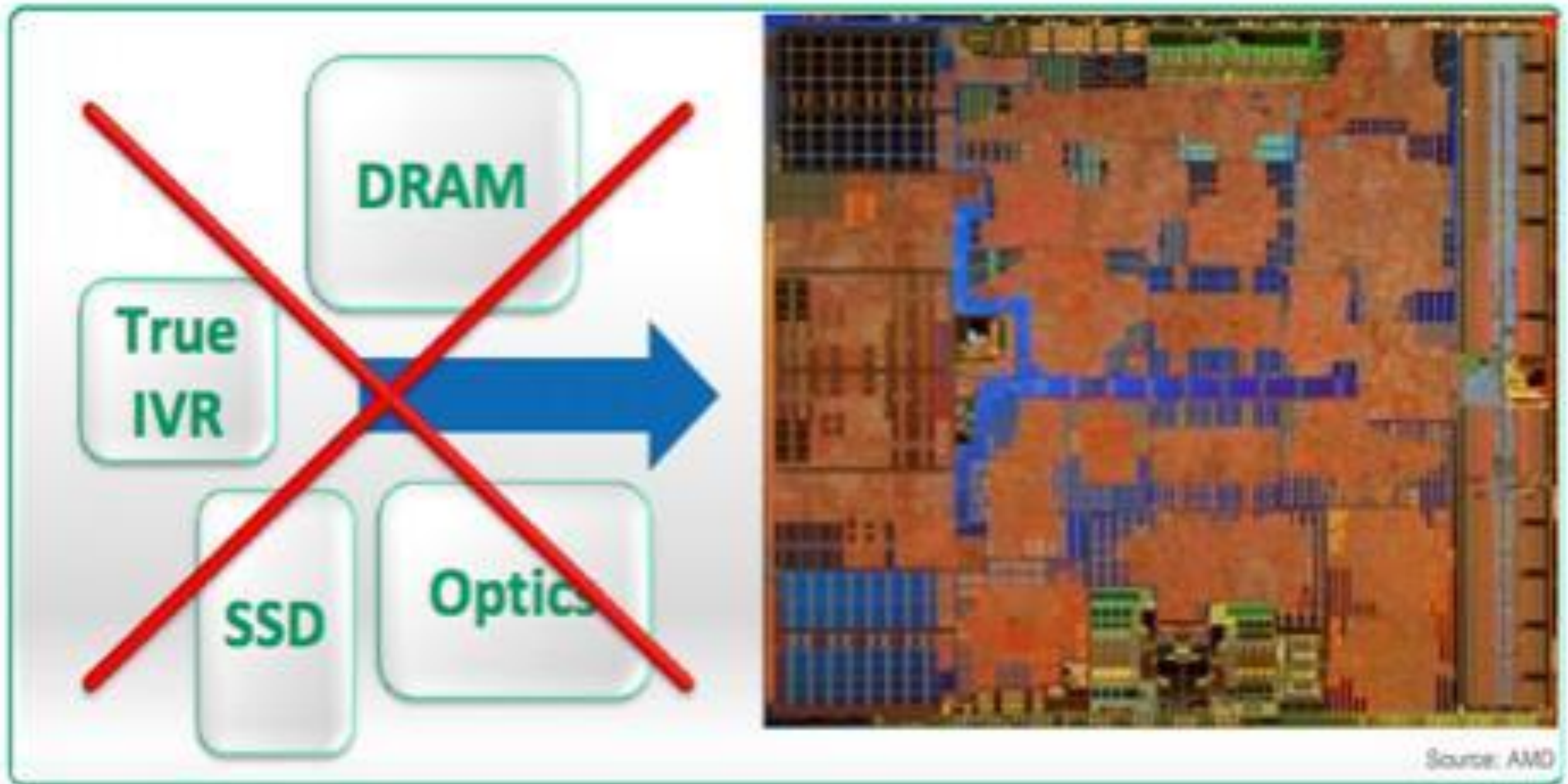
AMD 2014 3D-ASIP

Cost Trend Reversal



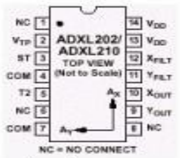
AMD 2014 3D-ASIP

The Apples & Oranges of SOC



AMD 2014 3D-ASIP

Internet Of Things



Accelerometer

Gyro

Pendulum Resistive Tilt Sensors

Piezo Bend Sensor

Metal Detector

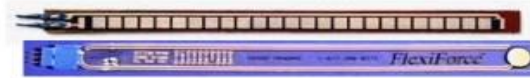
Gas Sensor

Gieger-Muller Radiation Sensor

Pyroelectric Detector

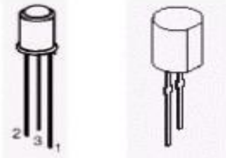
Digital Infrared Ranging

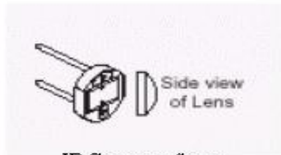
CDS Cell Resistive Light Sensor



Resistive Bend Sensors

UV Detector


IR Pin Diode



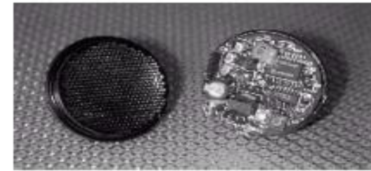
IR Sensor w/lens

Limit Switch

Mechanical Tilt Sensors

Touch Switch

Pressure Switch


Miniature Polaroid Sensor

IR Reflection Sensor

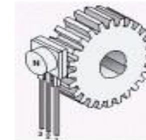
IR Amplifier Sensor

Thyristor

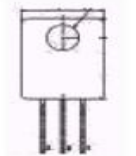
IRDA Transceiver

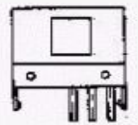
Magnetic Sensor

Magnetic Reed Switch


Hall Effect Magnetic Field Sensors

Polaroid Sensor Board

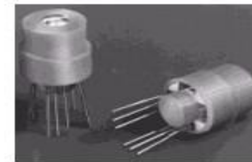

Lite-On IR Remote Receiver


Radio Shack Remote Receiver

IR Modulator Receiver

Solar Cell

Compass


Compass

Piezo Ultrasonic Transducers

Societyofrobots.com

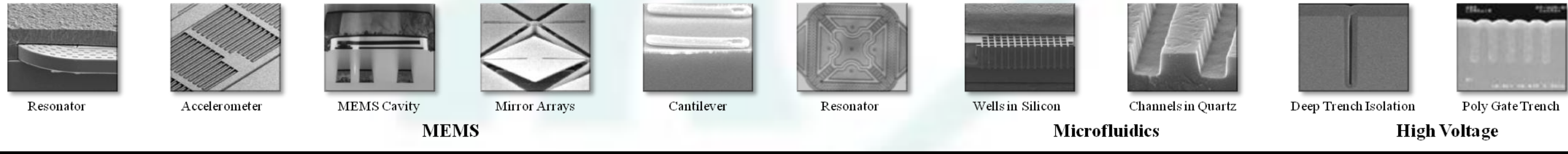
More Than Moore

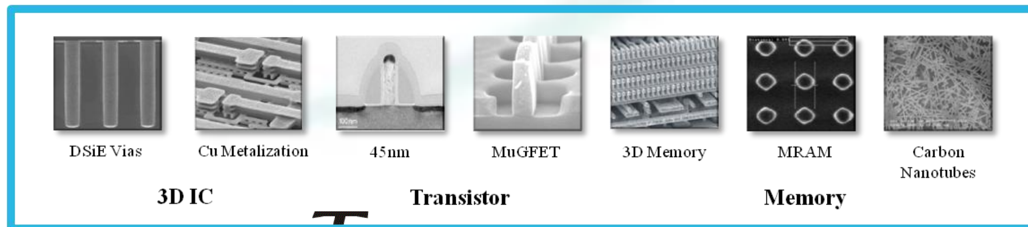
GEORGIA TECH PRC

1. THIN 2D AND 3D ACTIVES
2. THIN FILM PASSIVES
3. SYSTEM INTERCONNECTIONS
4. THERMAL INTERFACES AND STRUCTURES

OPTO SOP
LASER
PHOTODETECTOR
WAVEGUIDE
NANOMAGNETICS
CHIP-LAST EMBEDDED IC
DIGITAL SOP
THERMAL SOP
SYSTEM ON CHIP (SOC)
3D CAPACITORS
EBG & ISOLATION
ANALOG & RF SOP
GaAs RFIC
ANTENNAS & FILTERS
MEMS PACKAGING
MEMS
BIO-SENSOR
SILICON OR GLASS INTERPOSER
HIGH DENSITY I/O
3D ICs
POWER & BATTERIES

5. MULTI-FUNCTION MATERIALS
6. MIXED SIGNAL DESIGN AND TEST
7. MECHANICAL DESIGN AND RELIABILITY
8. POWER SOURCES





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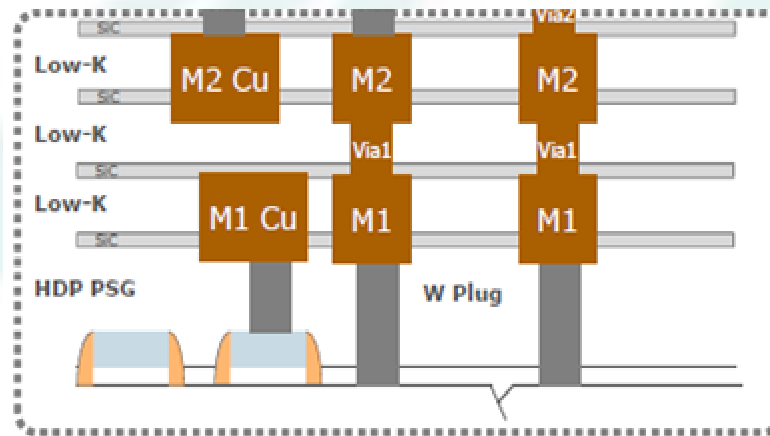
MORE THAN MOORE

The Fabrication Road to More Than Moore

Memories, CMOS, Photonics, III-V, Novel Materials, Microfluidics, MEMS, etc.

Build novel structures BEOL

Start with FEOL CMOS wafer



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Integration Paths: Additive Silicon and 2.5/3D

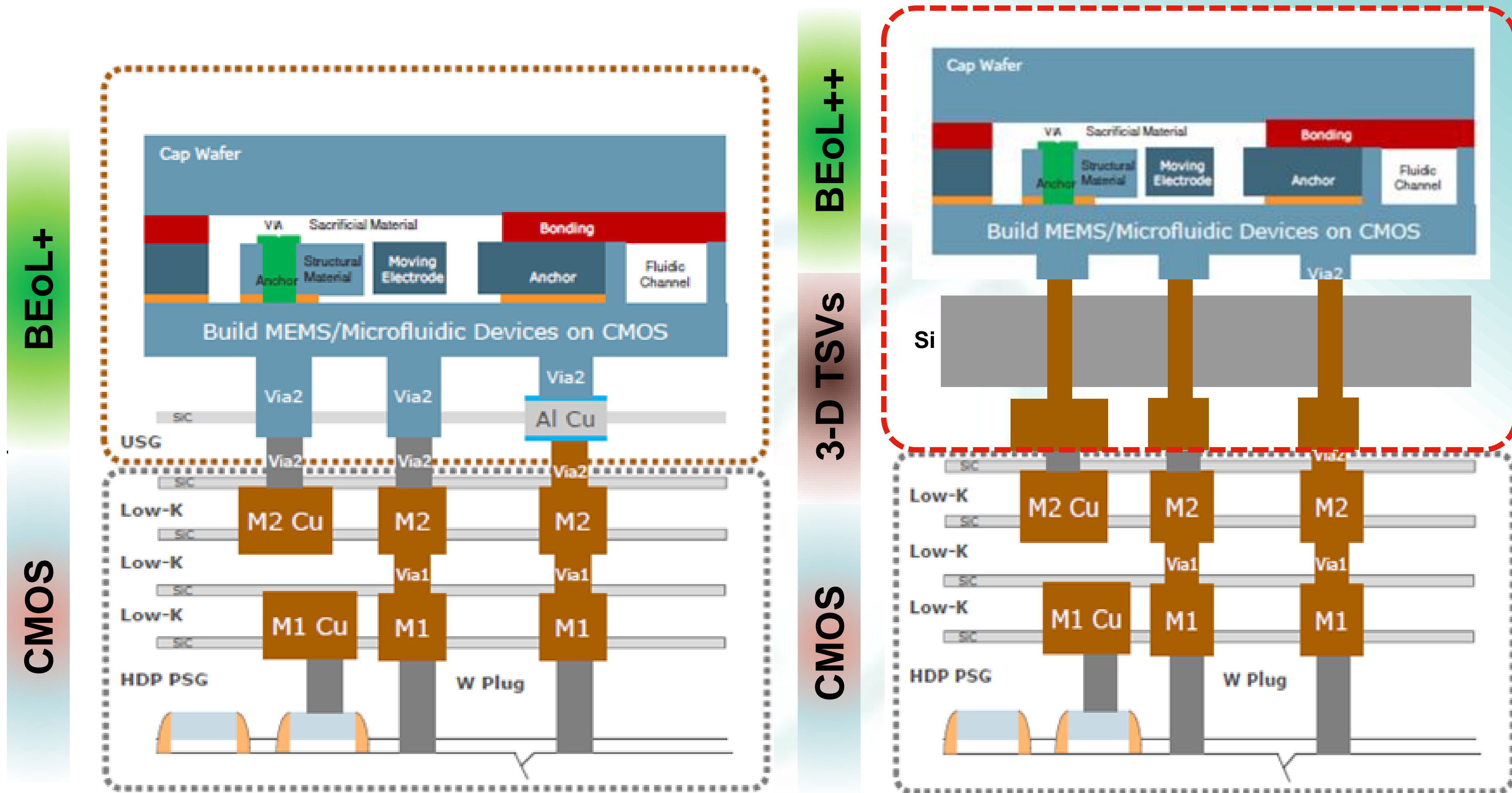

Figure 1: Non-digital devices built directly on CMOS (left), or built separately and joined through 3-D TSVs

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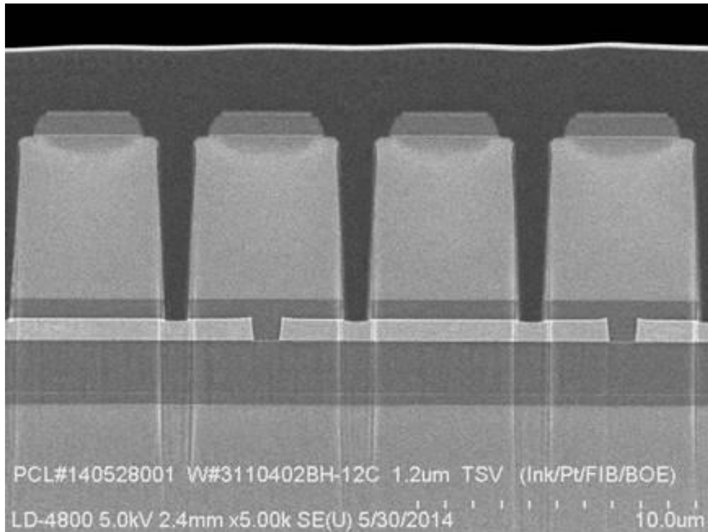
New Elements Introduced to Fabrication

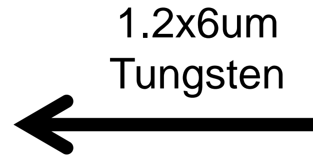
Typical CMOS Fab

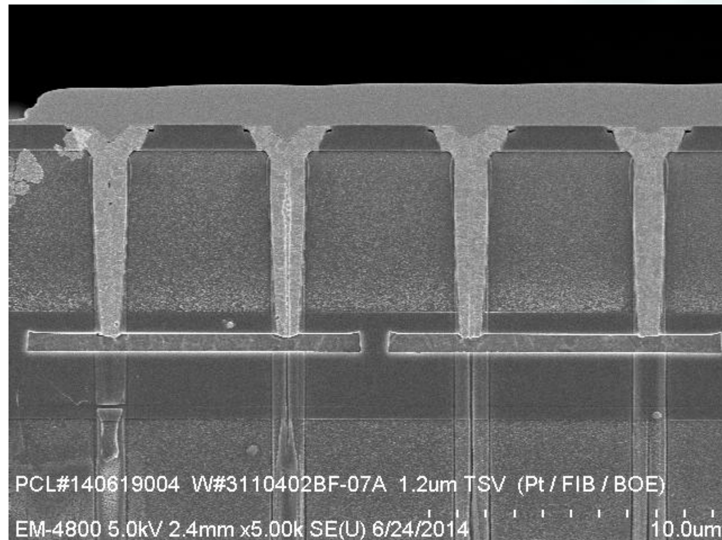
Additional at Novati

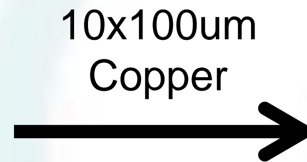
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bg	Hs	Mt									
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

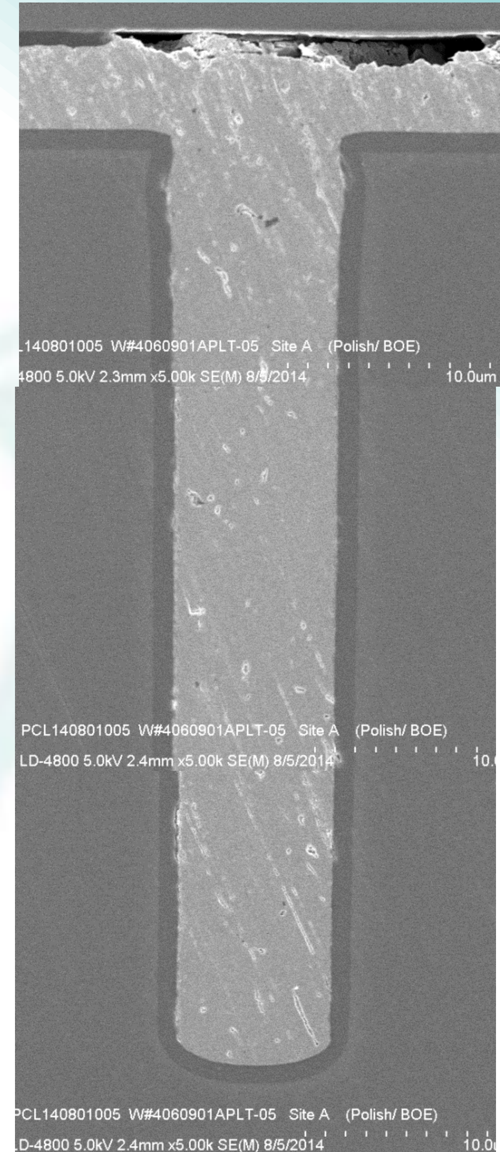
TSV Insertion to Create 2.5/3D Assemblies











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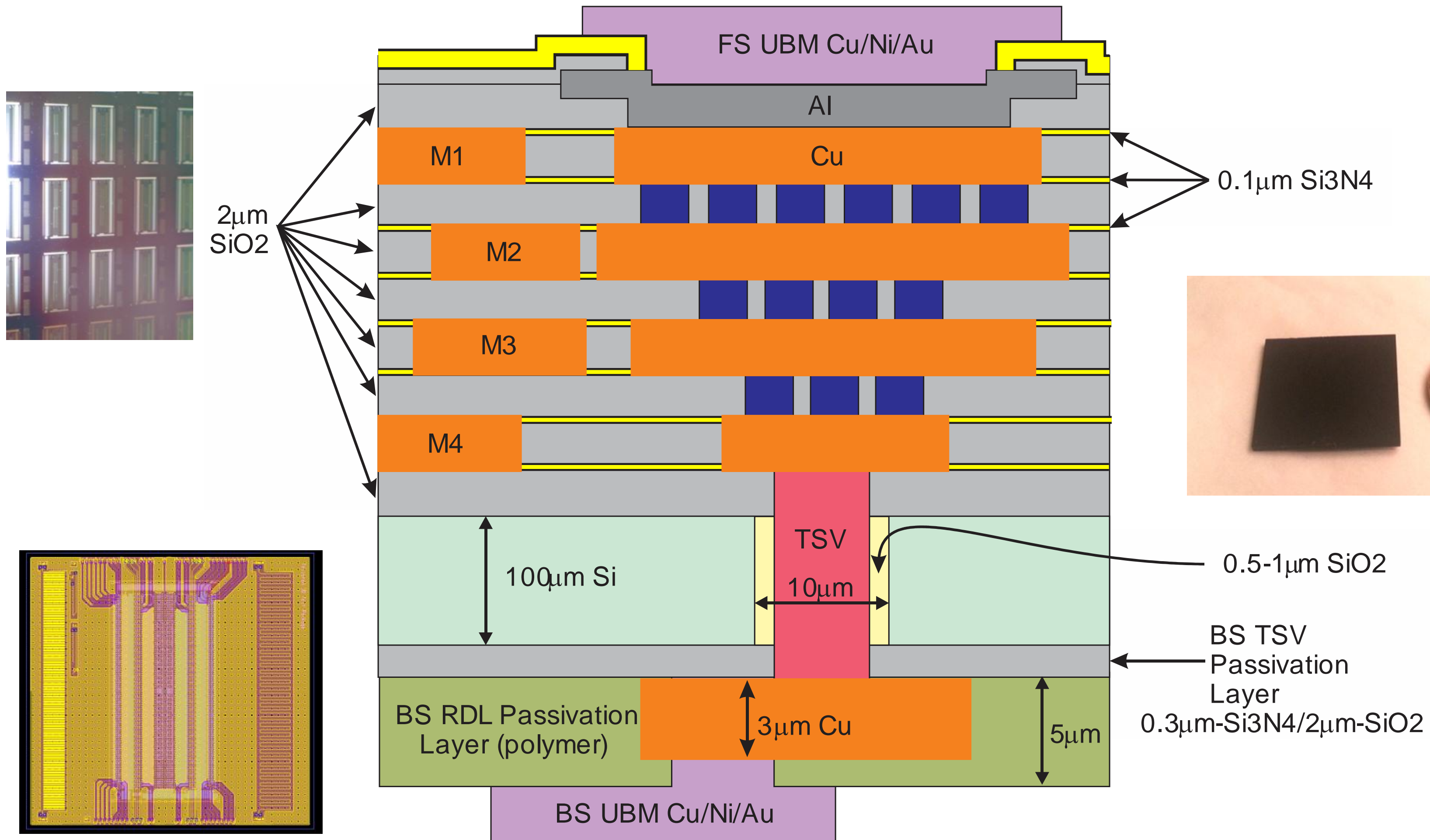
Si Interposers



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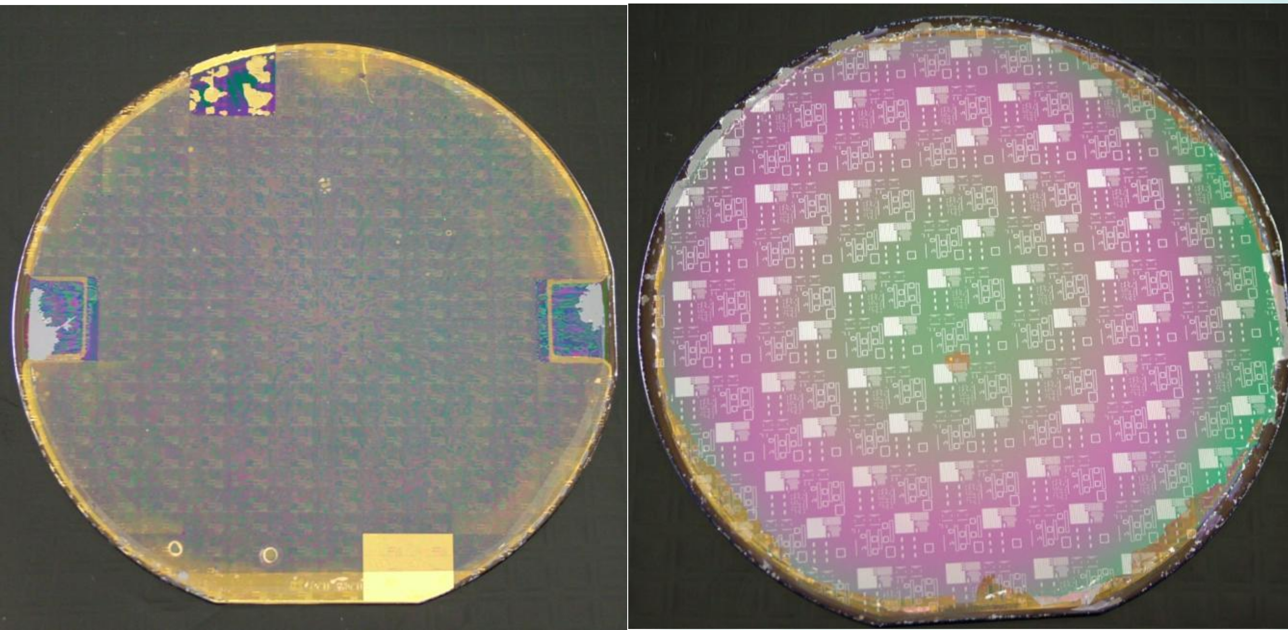
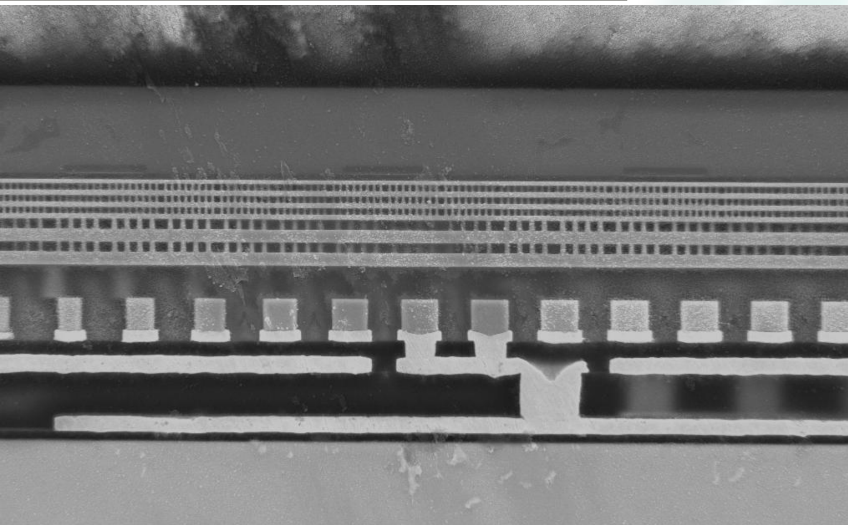
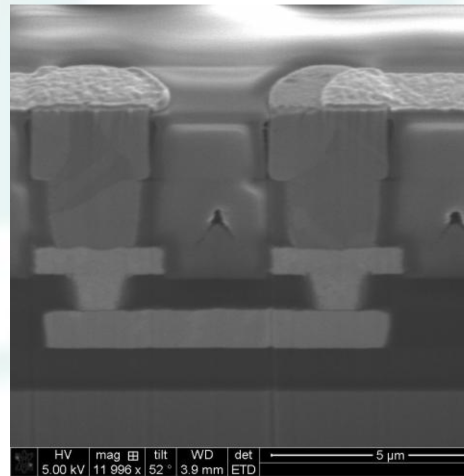
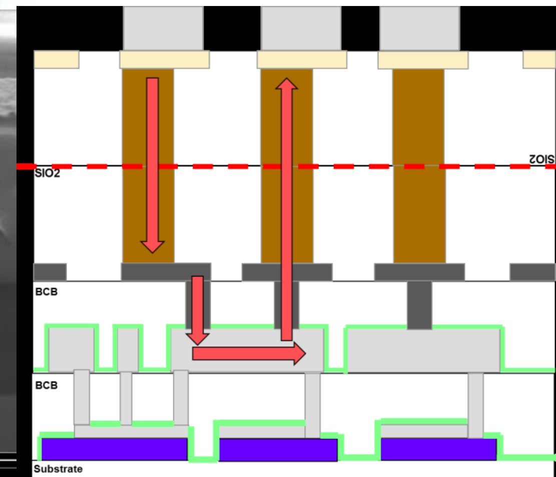
Mixed CMOS-3/5 100mm InP/CMOS



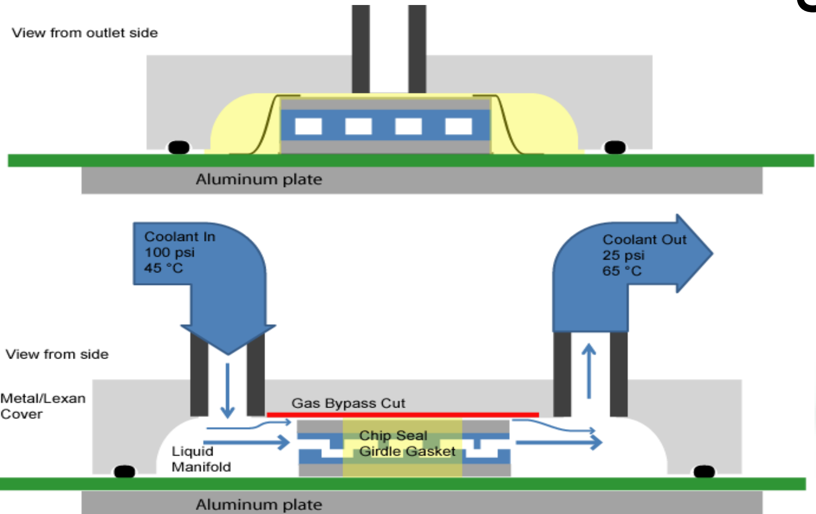
- GaN
- 3D CMOS/InP/GaN
- GaAs
- Graphene

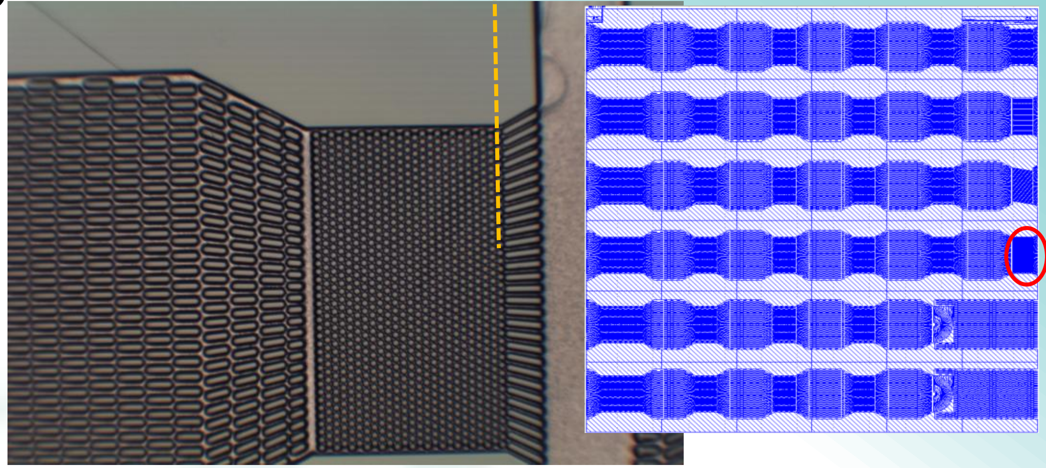


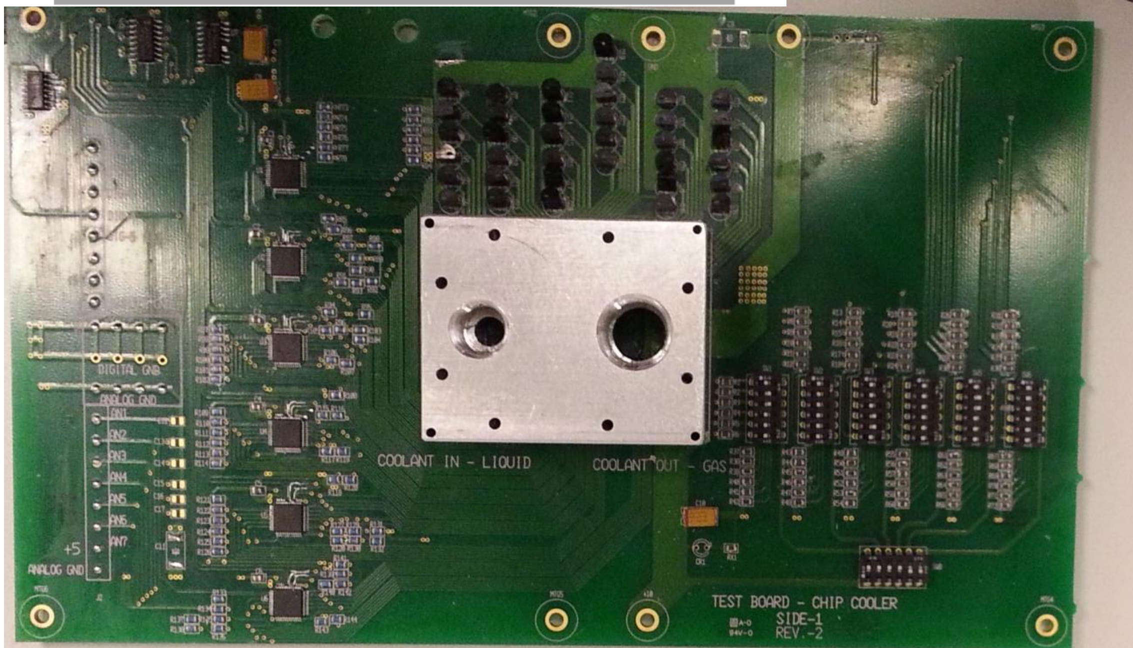


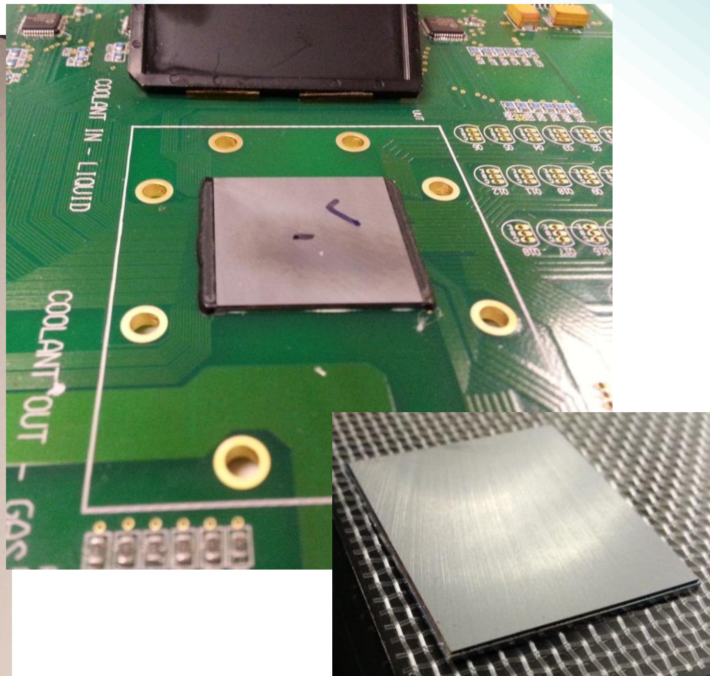


Advanced 3D Cooling









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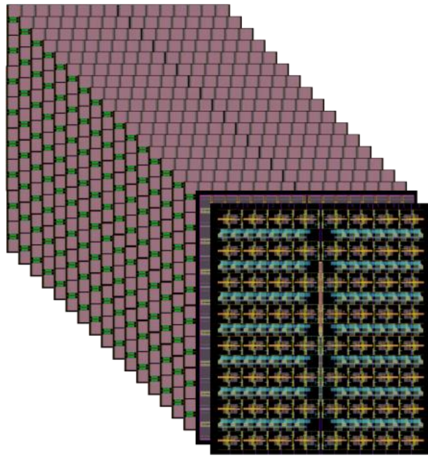
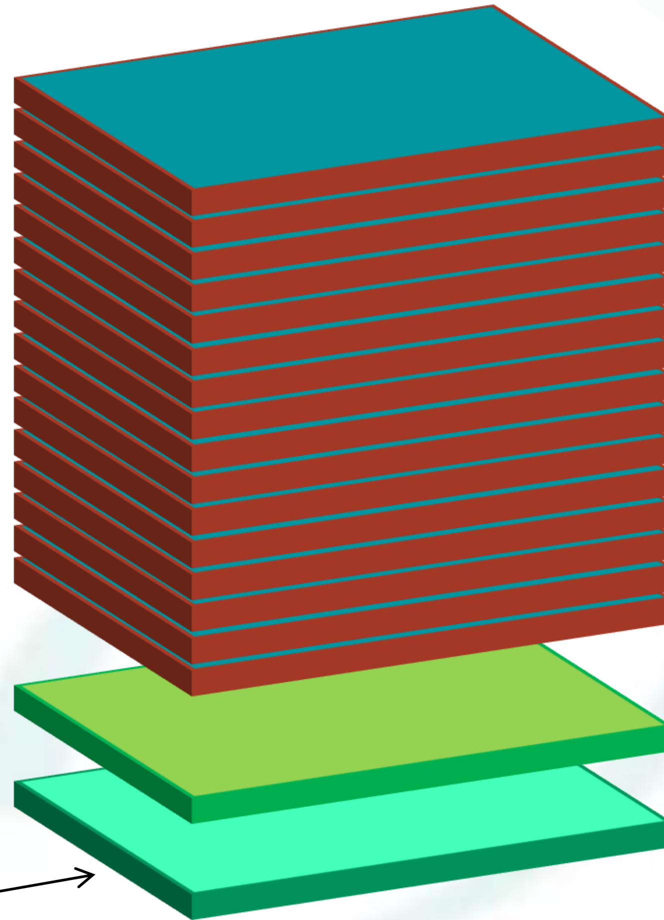
DiRAM4 “Dis-Integrated” 3D Memory





DRAM layers
4xnm node

2 million vertical connections per lay per die

I/O layer contains: I/O, interface logic and R&R control CPU. 65nm node

Controller layer contains: sense amps, CAMs, row/column decodes and test engines. 40nm node

Better yielding than 2D equivalent!

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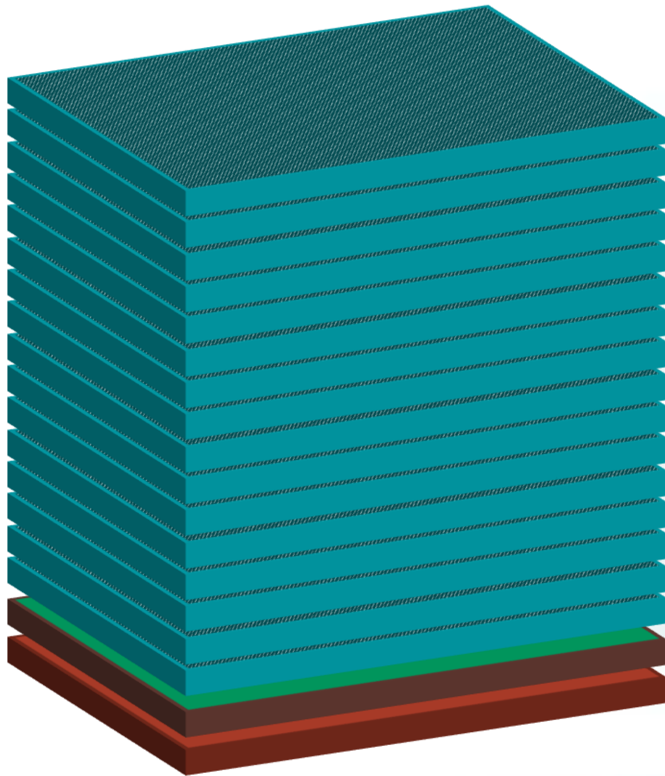
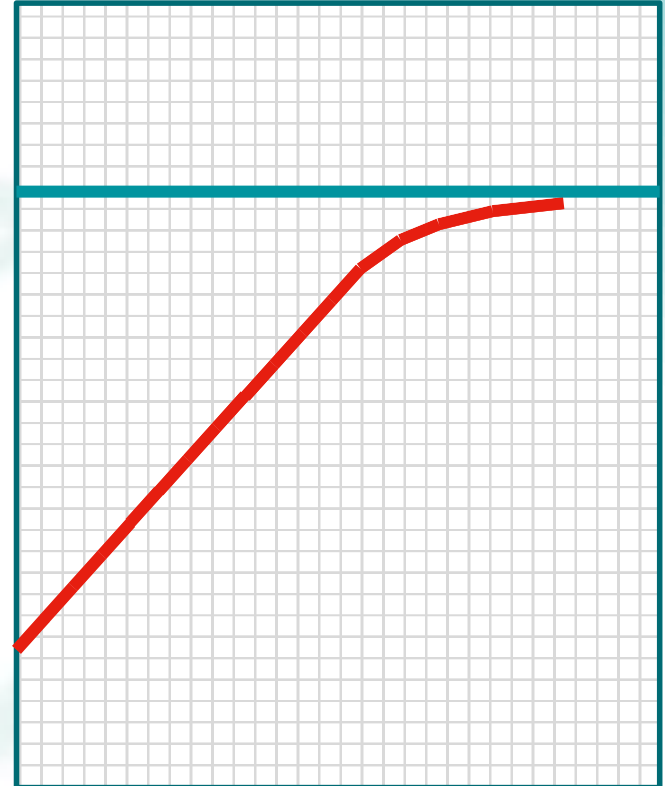
Bi-STAR Repair Improves Yield





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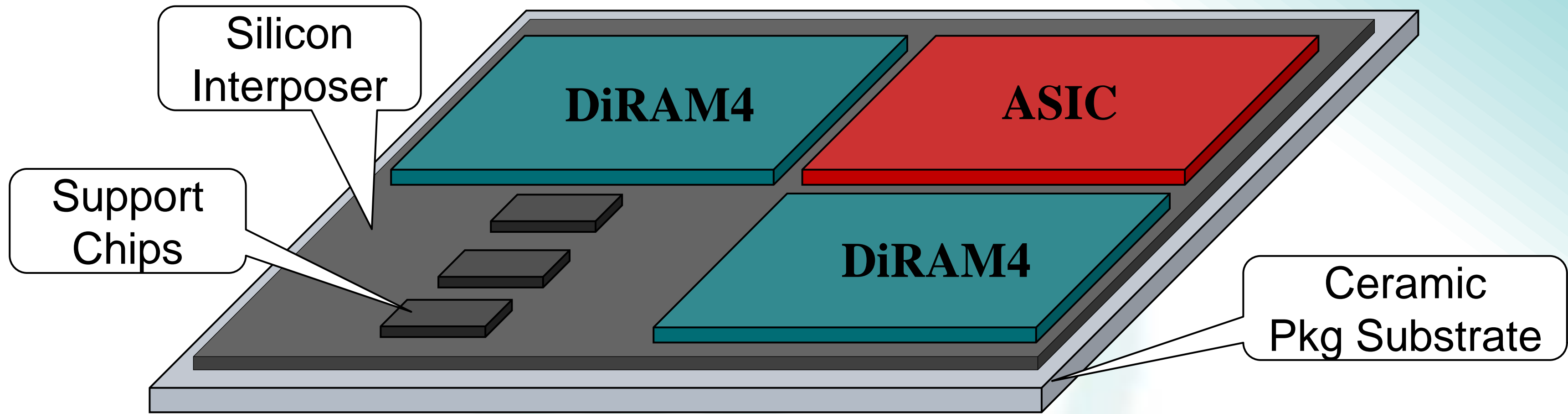
HPC Processor Modules



Si Interposer-based Ceramic Package

e.g. DiRAM4 plus Custom Processor

50 µ - 100 µ pitch Copper Pillar Die-to-Interposer-to-Die Interconnect

~ 10000 Connections – Mostly die-to-die inside package

~250 µ pitch C4 Bump Interposer-to-Ceramic Package Substrate Interconnect

~ 2000 Connections – Lots of replicated power connections

1 mm pitch Solder Bump Package Substrate-to-Customer PCB Interconnect

Several Hundred of Connections

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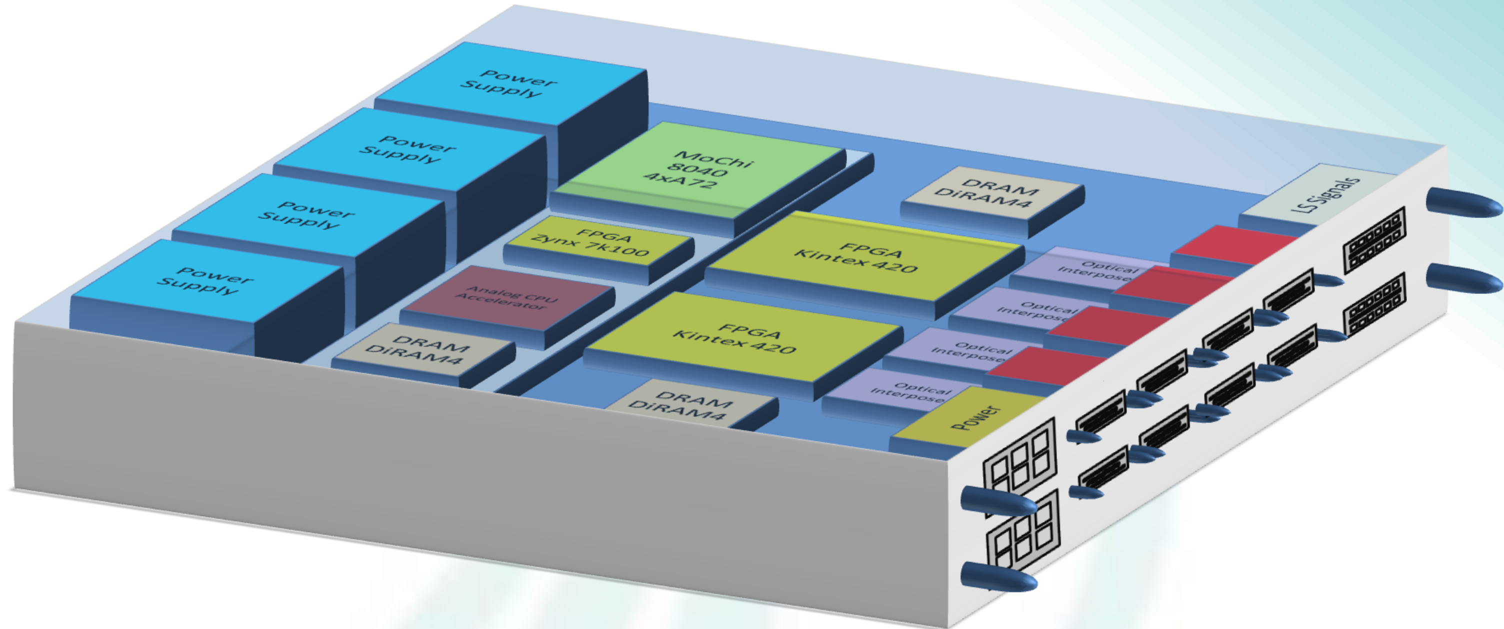
And Full Subsystem Modules



System Modules

Multiple Packages and /or Die
on High Performance Organic Interposer/Substrate with System Connectors
(Electrical: Card edge or Plugs, Optical: Fiber-optic Cable connectors)

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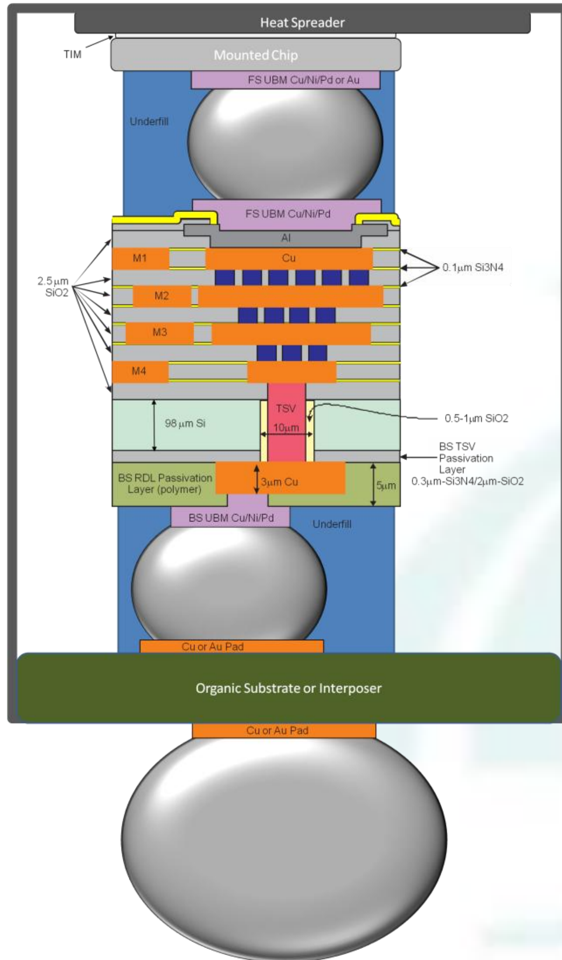
Supply Chain



Donor Die
Donor Die Bump
Interposer UBM Topside
Interposer
Interposer UBM Bottomside
Interposer Bump
Interposer Underfill
Donor Die Underfill
Organic Substrate
Substrate Bump
TIM
Package Lid
Carrier Wafer
Singulation
Bond/Debond

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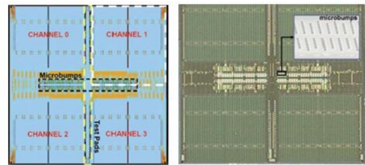
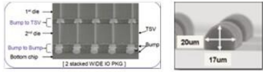
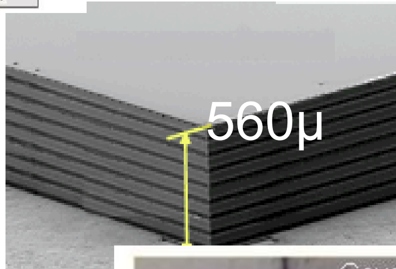
2.5/3D CHANGE IS HERE

The Semiconductor Revolution

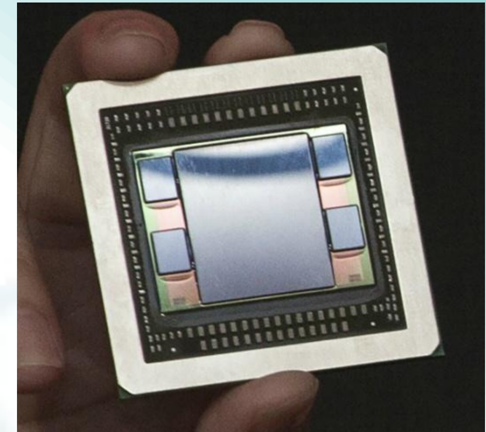




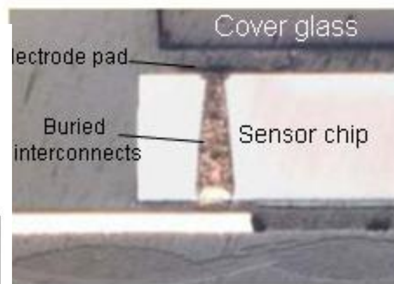


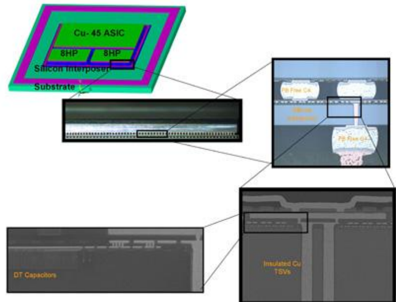
Samsung
16Gb NAND flash (2Gx8 chips), Wide Bus DRAM, VNAND

Hynix
HBM DRAM

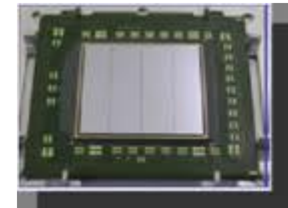


Intel
CPU + memory

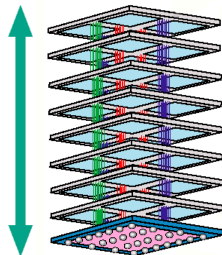


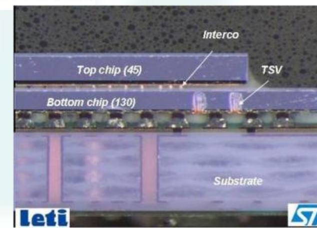


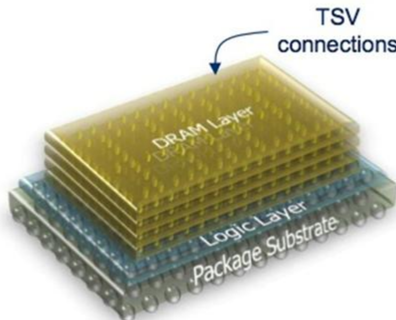
Sony
CMOS Sensor



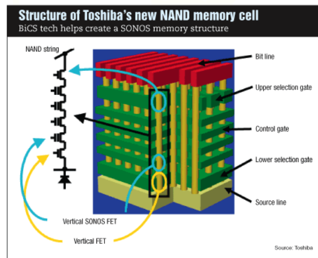
Xilinx
4 die 65nm interposer

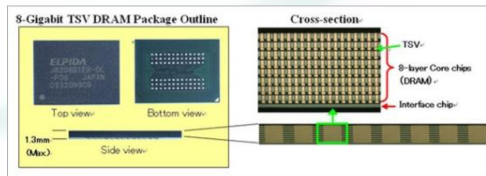






AMD
Radon R9





IBM
RF Silicon Circuit Board / TSV
Logic & Analog

Toshiba
3D NAND

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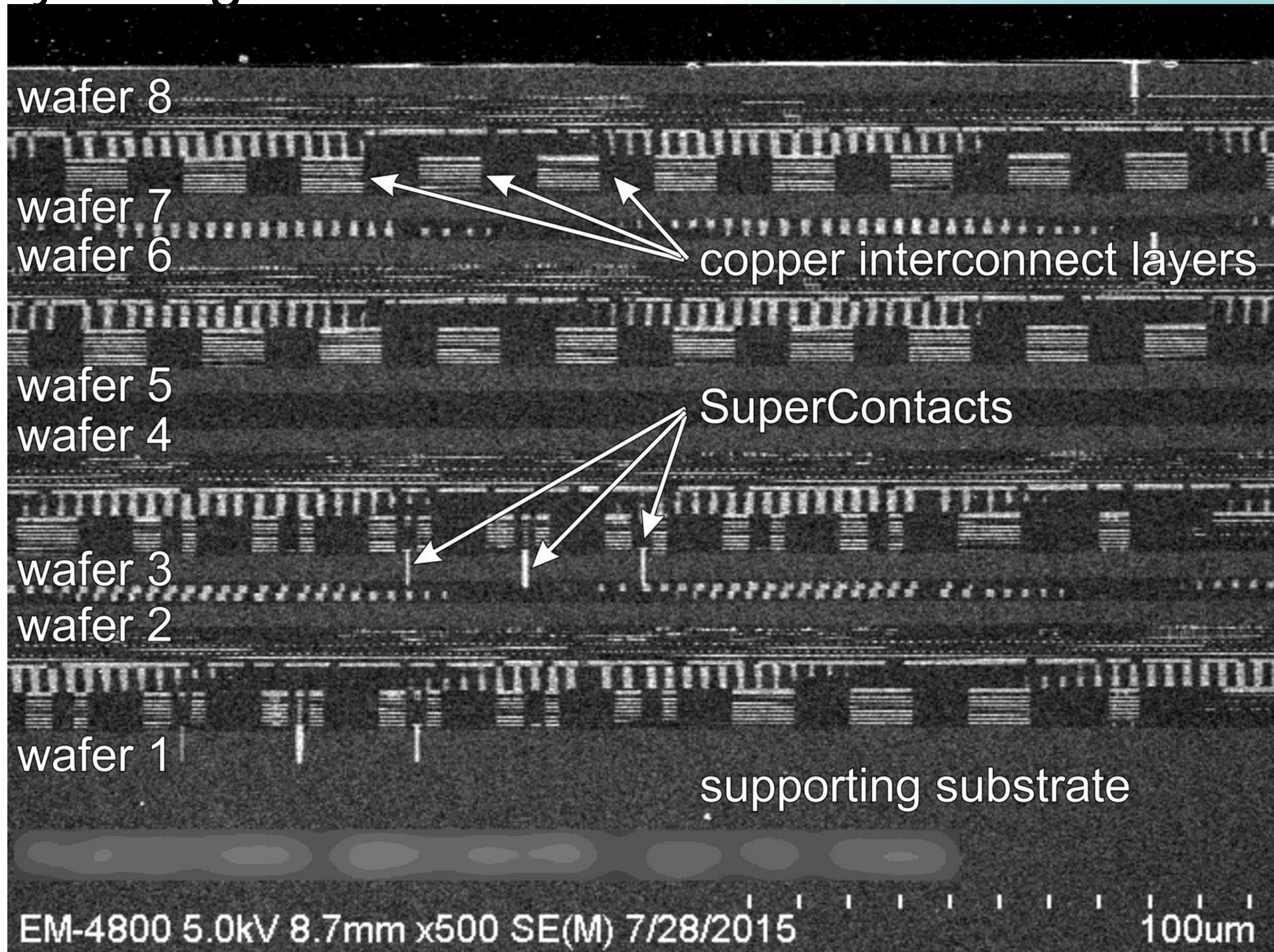
8 Layer Logic Stack



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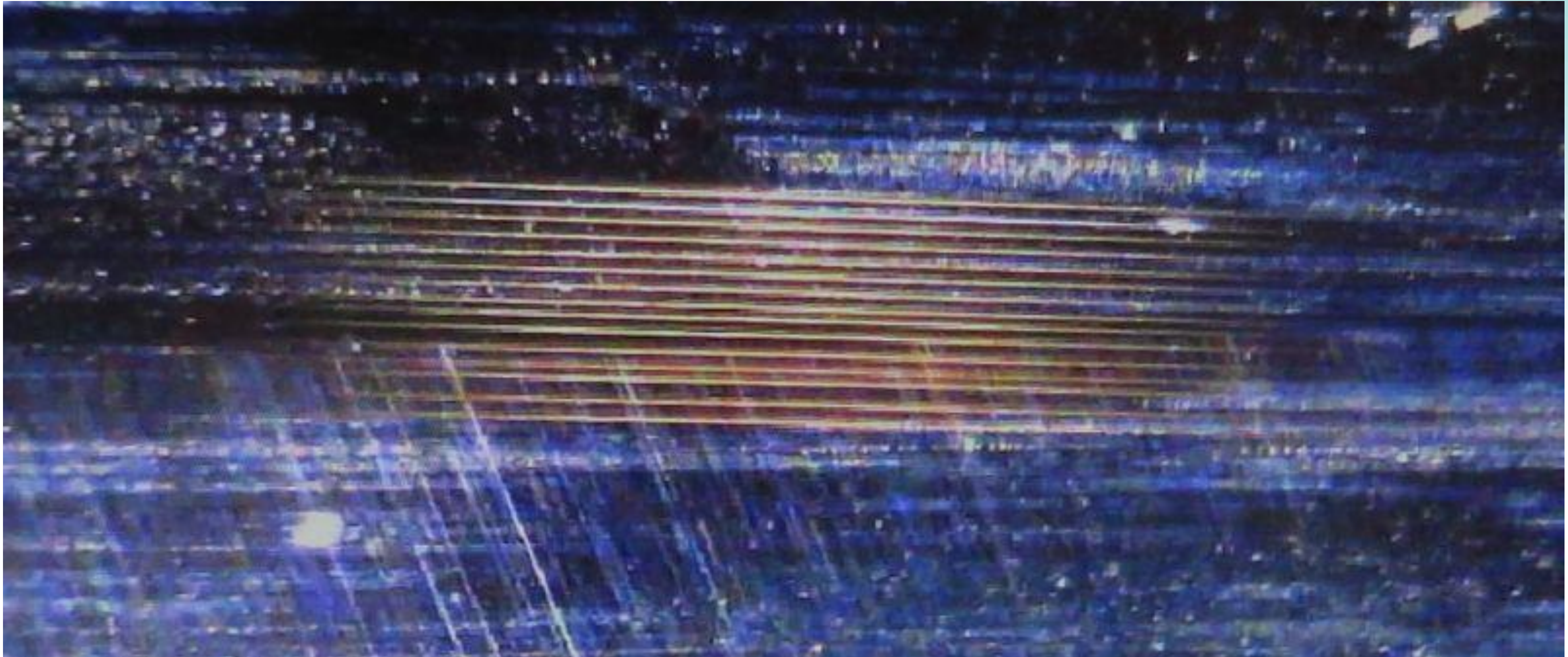
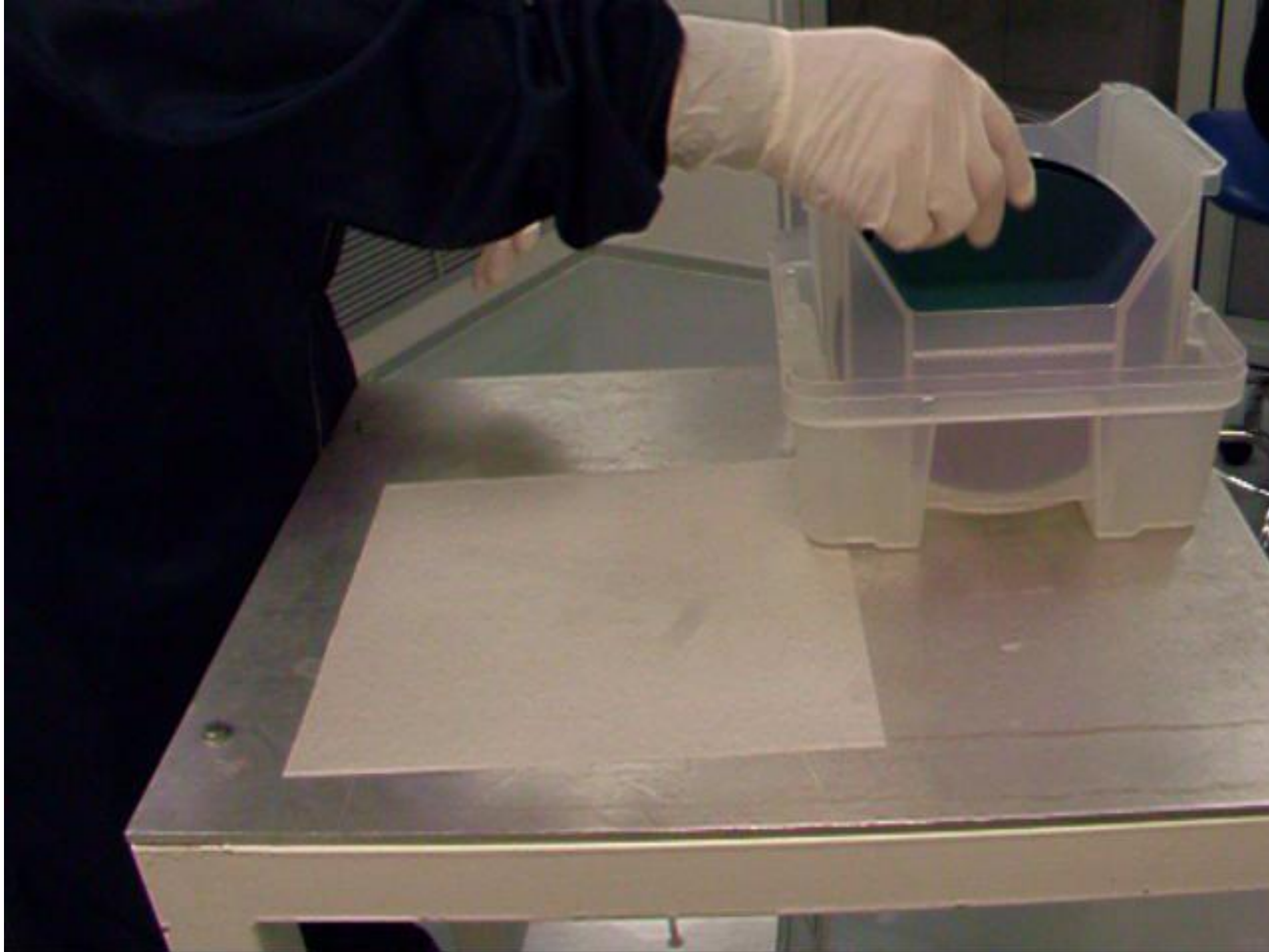
16 Layer Mechanical Device Stack



Bonding in Action



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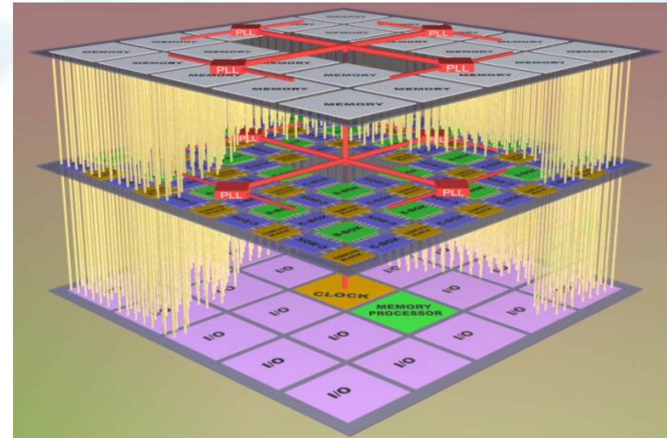
Summary

- 2.5/3D market is in the adoption cycle
  - Moving from novelty to mainstream
- Drivers are:
  - Heterogeneous integration
  - SWaP
  - Increasing performance
  - Lower system costs
- First markets are:
  - Logic – Memory
  - Sensors
- Significant industry shifts will happen
  - Silicon circuit cards with “Lego” blocks



Austin Facility Overview

- 110 Employees: 90 in Ops and Engineering
- Over 150 production grade tools
- 68,000 sq ft Class 10 clean room
- 24/7 operations & maintenance
- Manufacturing Execution Systems (MES)
- IP secure environments, robust quality systems
- ISO certified/ITAR registered
- Full-flow 200mm silicon processing, 300mm back-end (Copper/Low-k)
- Process library with > 25000 recipes
- Novel materials (ALD, PZT, III-V, etc)
- Copper & Aluminum BEOL
- Contact through 193nm & IR lithography
- Silicon, SOI and Transparent MEMS substrates
- Electrical Characterization and Bench Test Lab
- Onsite analytical tools and labs: SIMS, SEM, TEM, Auger, VPD, ICP-MS, etc

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