Optoelectronic Multi-Chip Module Demonstrator System

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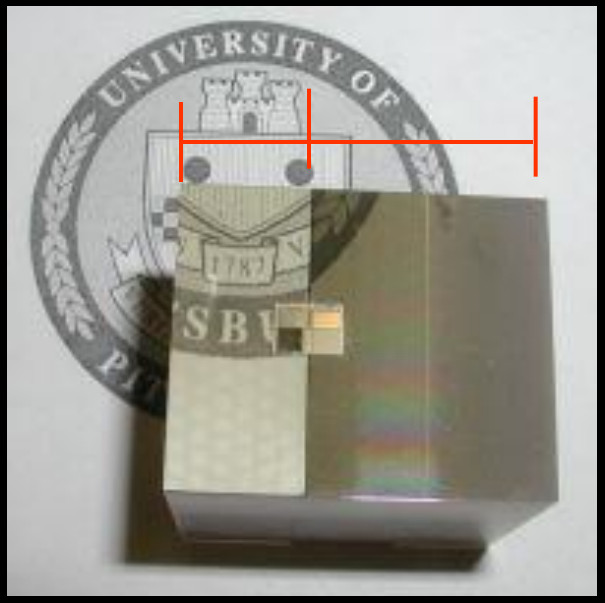
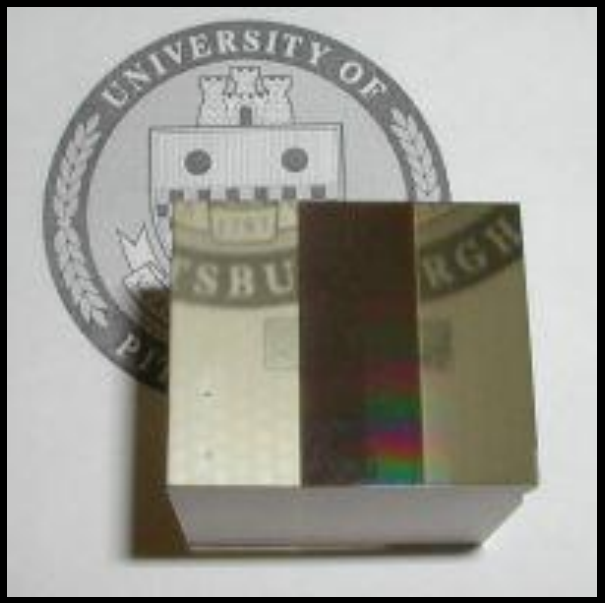
Talk Overview

- Chip-to-chip optoelectronic interconnection and packaging
  - “Optoelectronic Multi-Chip Modules”
  - Based on *fiber image guides*
    - Forms interconnect medium and structure of package
  - Goal:
    - Tightly integrated, rugged, and easily manufacturable (passive alignment)
- Fabrication and assembly of a demonstrator prototype
  - Goal:
    - Characterize OE behavior of system



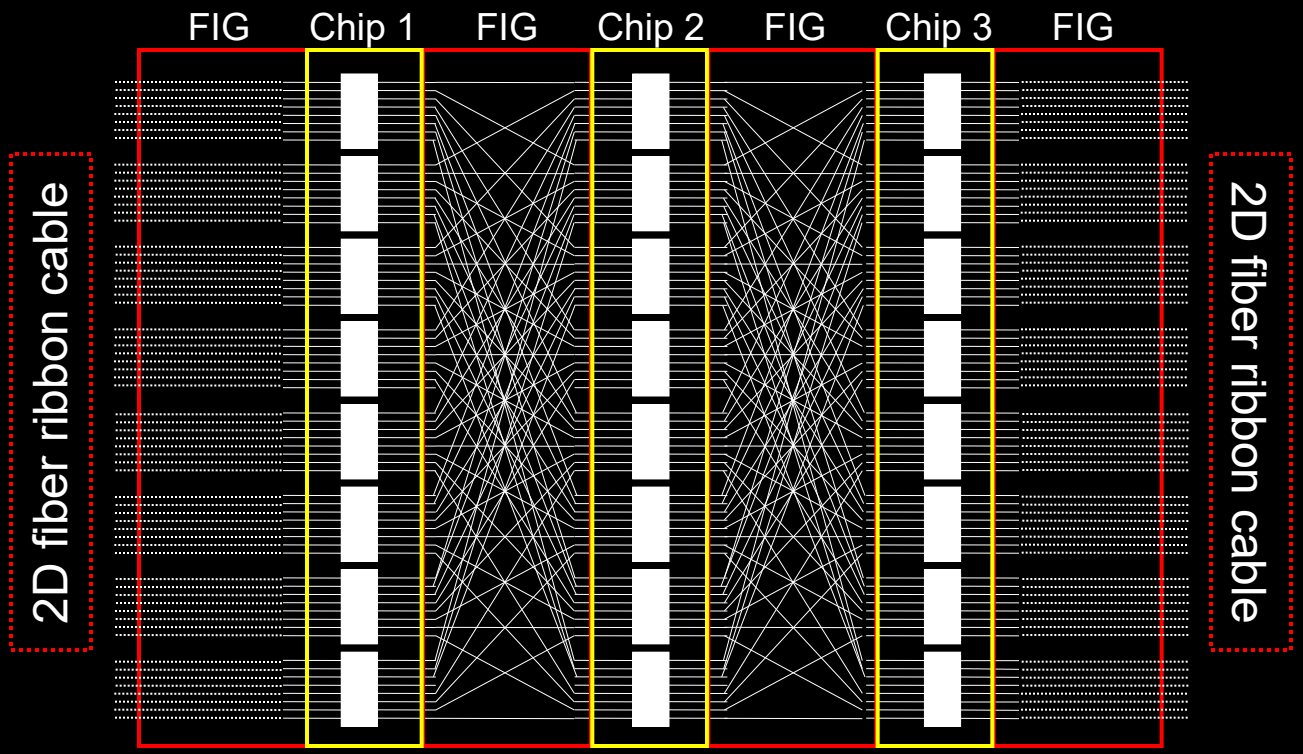
Top



Bottom

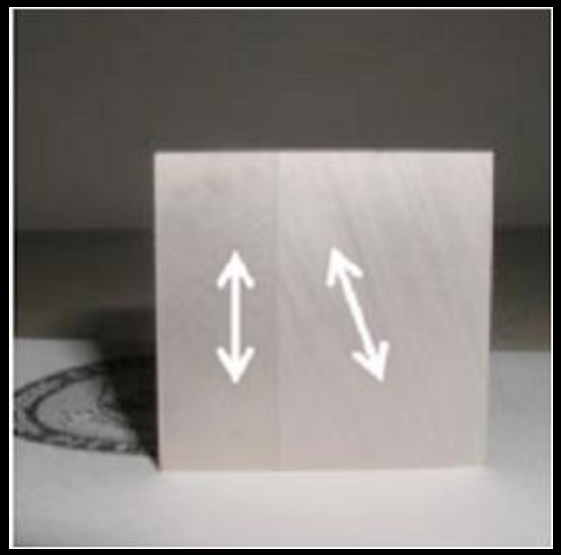
OE-MCM Demonstrator System

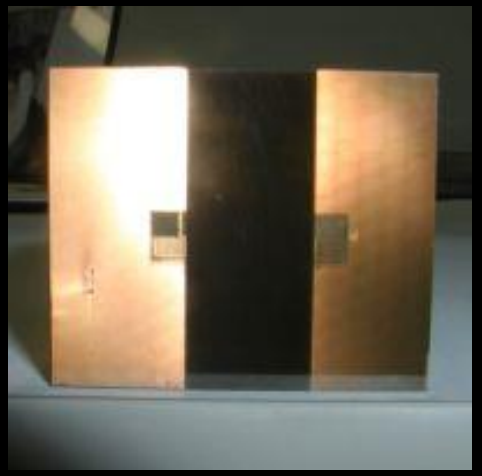
- 64-channel optical crossbar switch as 3-element OE-MCM
- Each identical element
  - Has 8x8 array of detectors and VCSELs at 250 um
  - Implements eight independent 8-channel switches (“rows”)
  - Each chip aligned orthogonal to its adjacent chip
- 2D fiber ribbon cable (8x8) carries optical data in/out of MCM

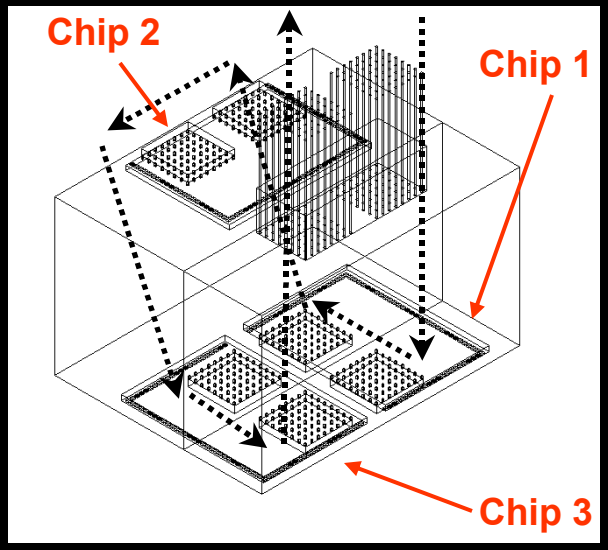


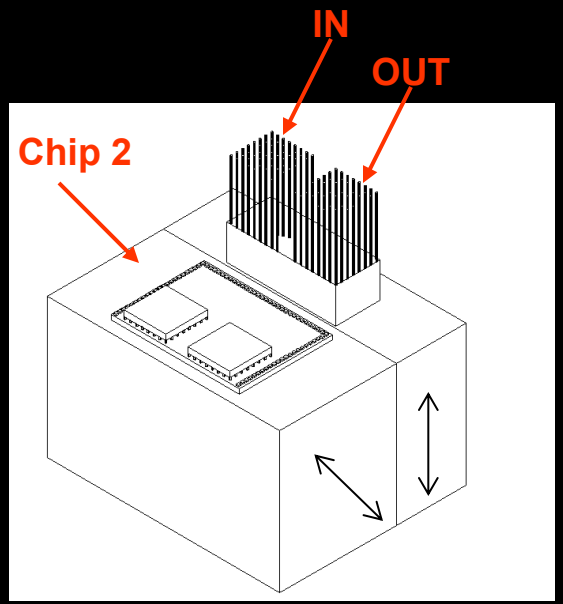
3-stage switch architecture

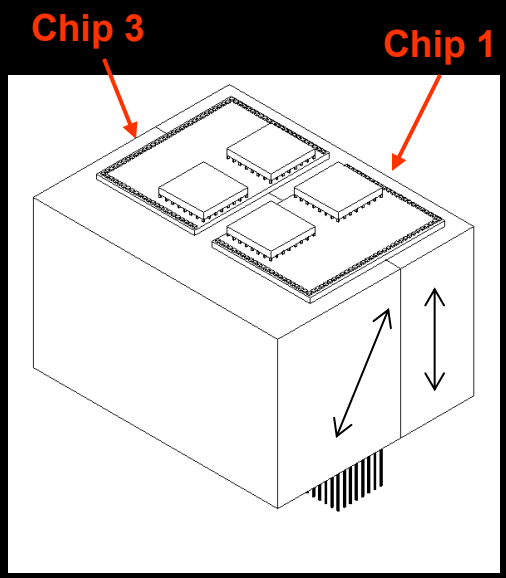
OE-MCM Interconnect Topology





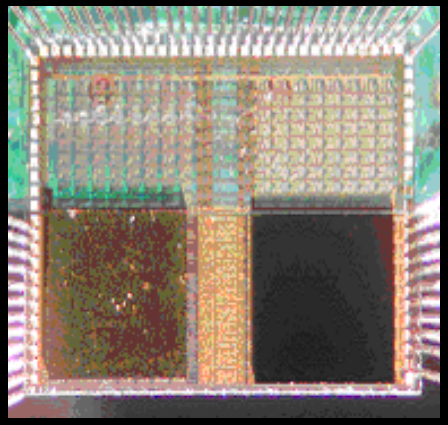




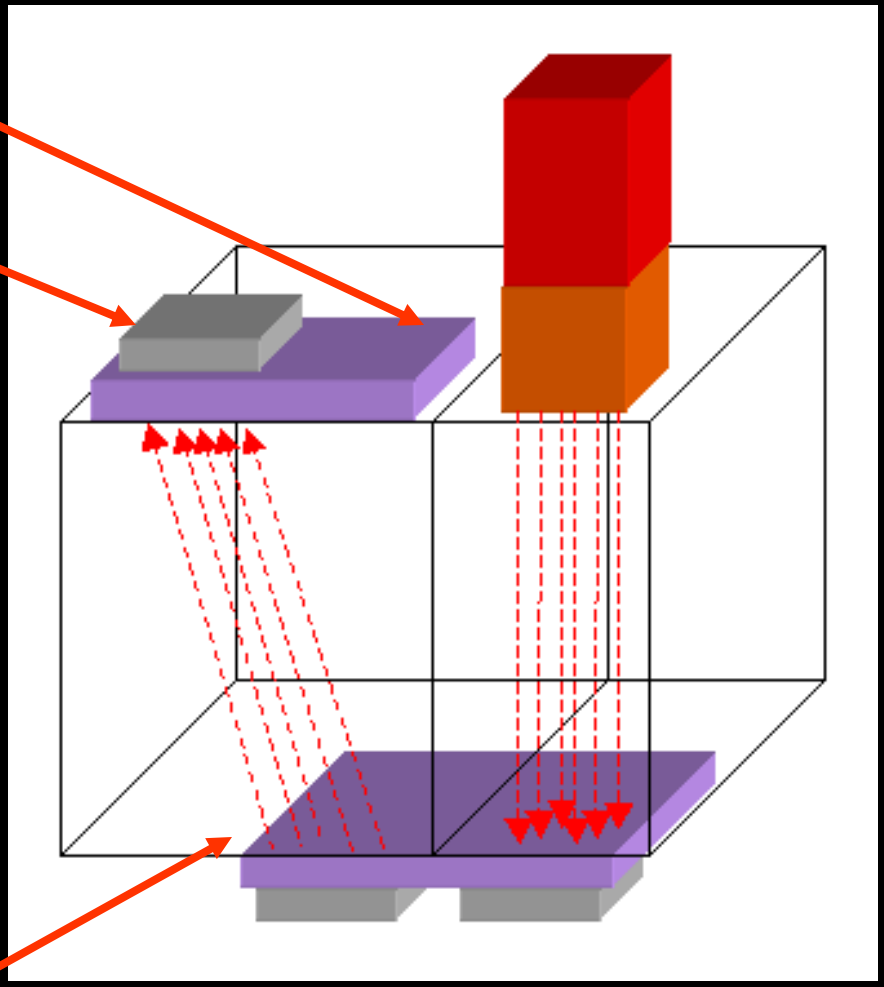


OE-MCM Fabrication and Bonding

- Digital/analog on CMOS chip
- Flip-chip bond OE chips to CMOS die
- Epoxy assembled elements to sides of image guide glass
- Bump-bond CMOS chips to PCB (supplies, electronic I/O)



Assembled “switch chip”

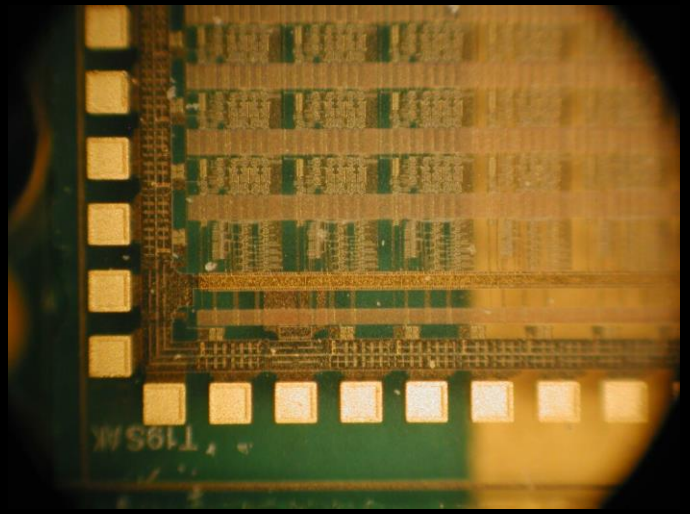


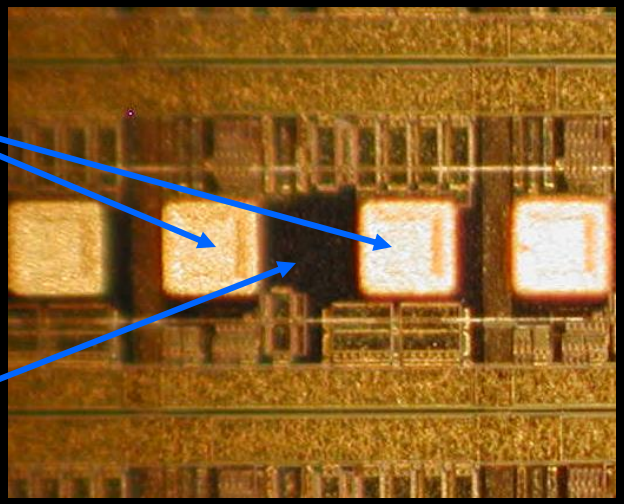
8x8 channel array

MCM cross section

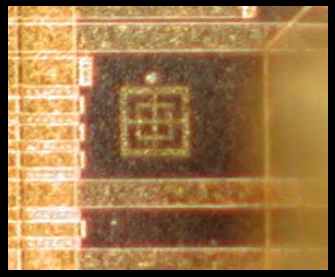
OE Element Fabrication

- CMOS chip has optically transparent substrate
- Peregrine Semiconductor UTSi process
- VCSELs and detector arrays FC bonded to top surface
- Metal alignment marks on die



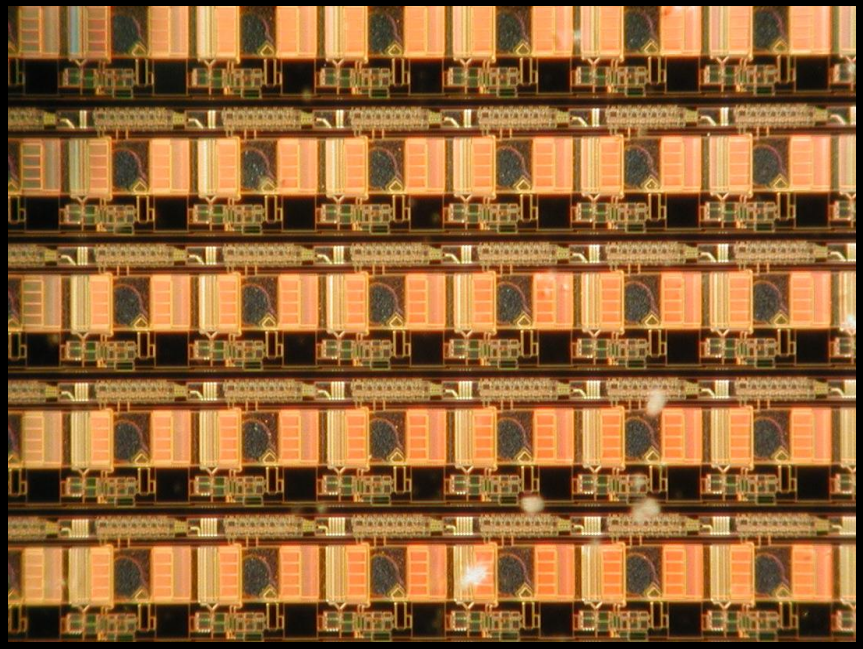


VCSEL site

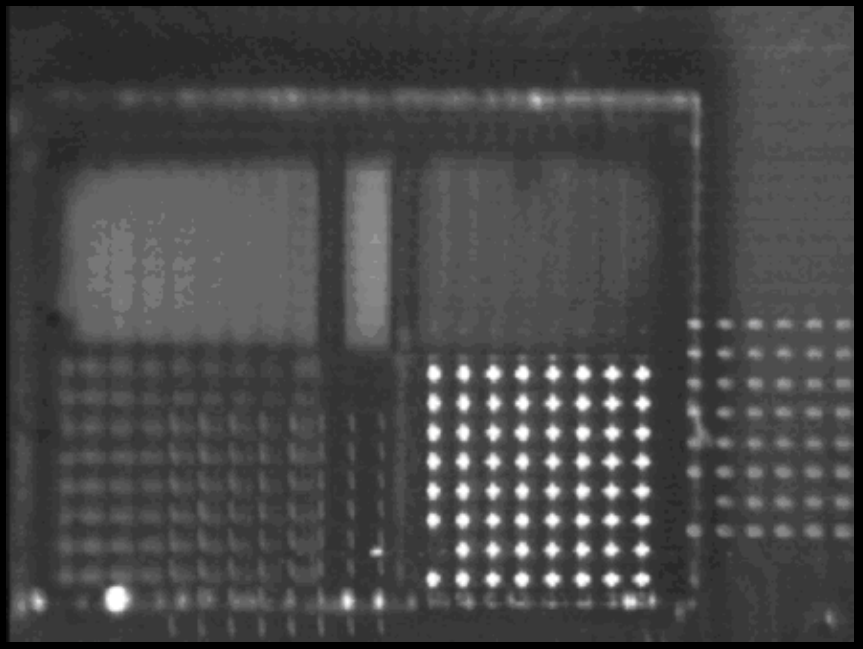


Passive alignment mark

Receiver/VCSEL arrays



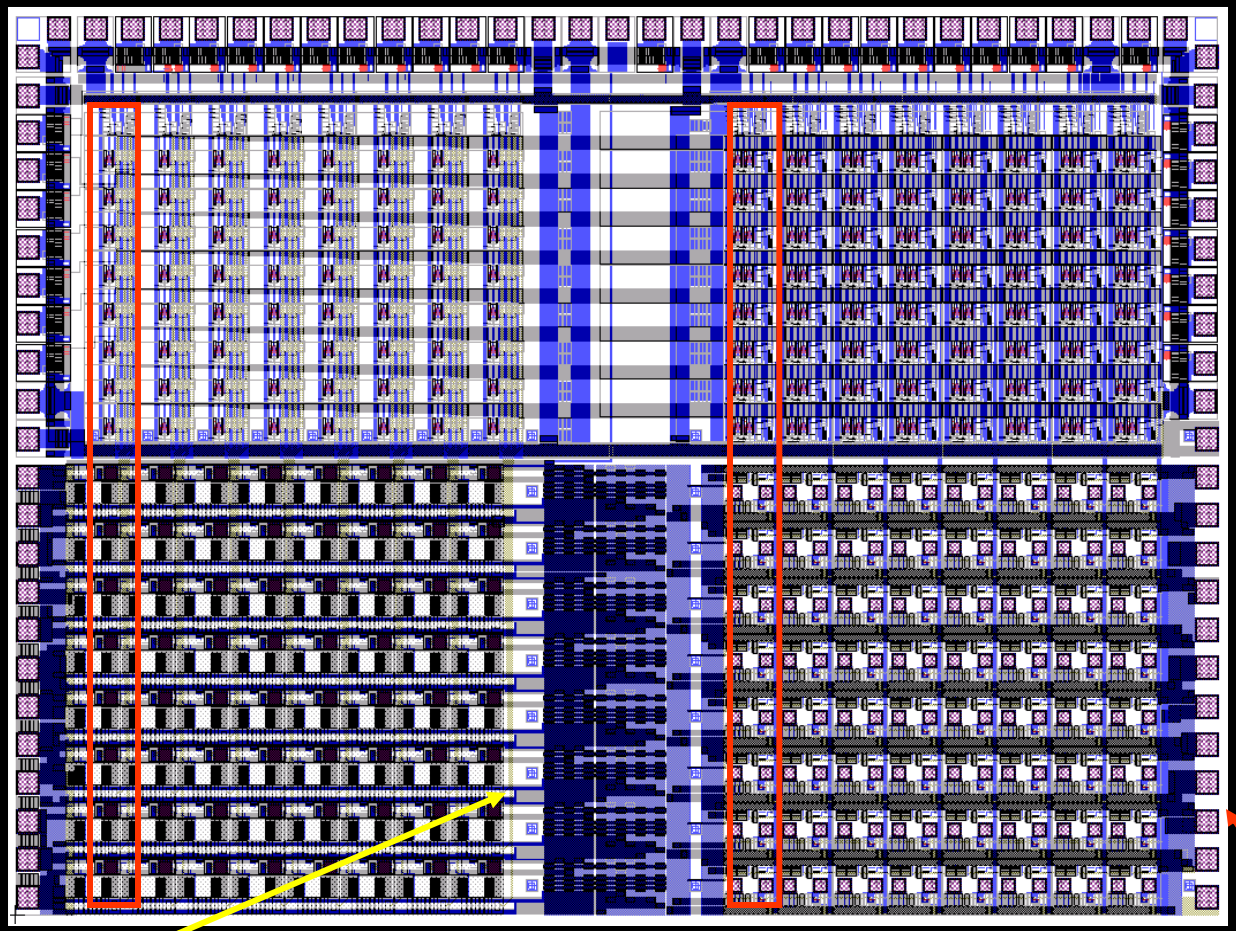
Bottom view of chip showing detectors



Bottom view of chip showing VCSEL array

Switch Chip Layout and Floorplan

Switching logic and switch configuration memory



Receiver section

Driver section

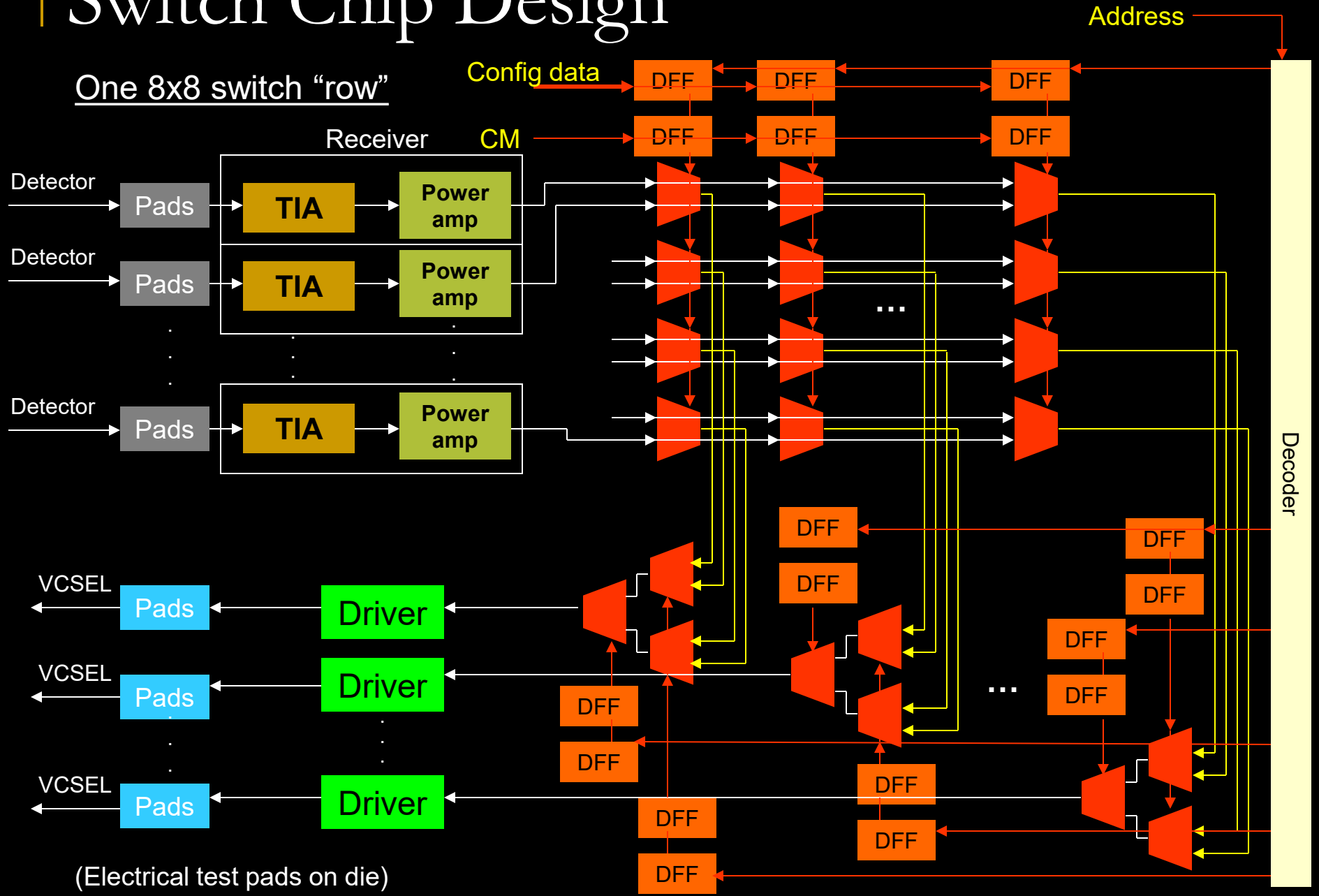
Alignment marks

Chip layout

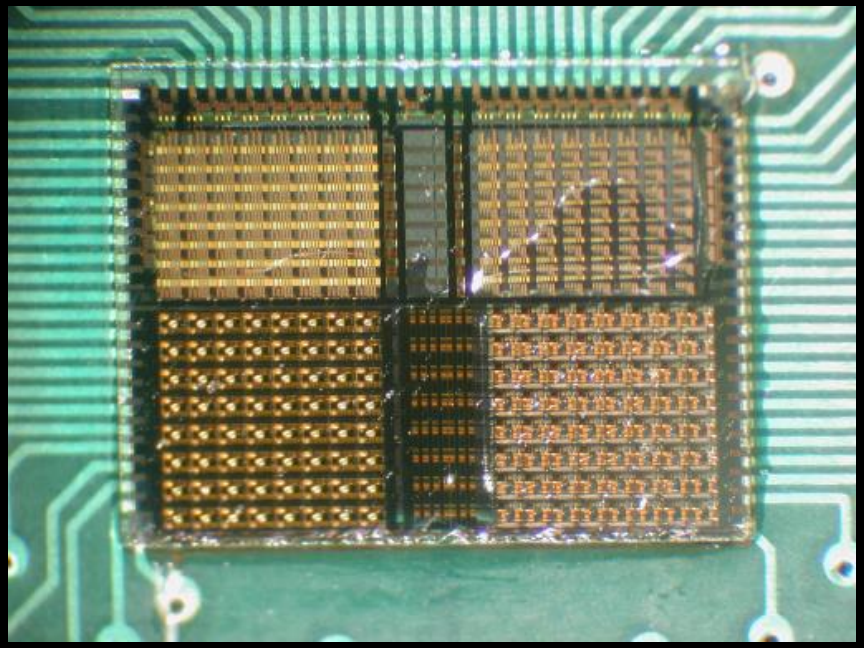
4 x 5.5 mm

Padframe

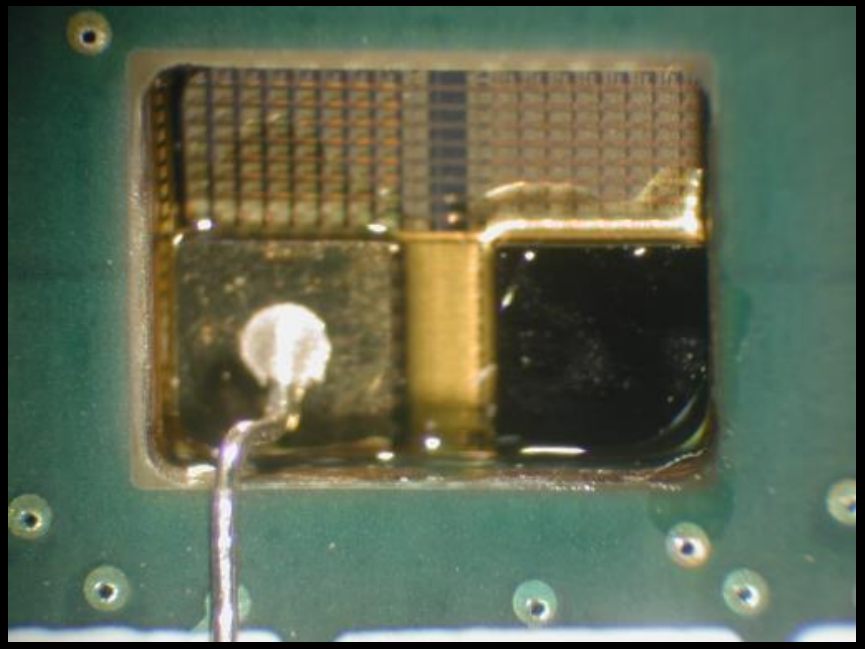
Switch Chip Design



Chip-on-Board Mounting

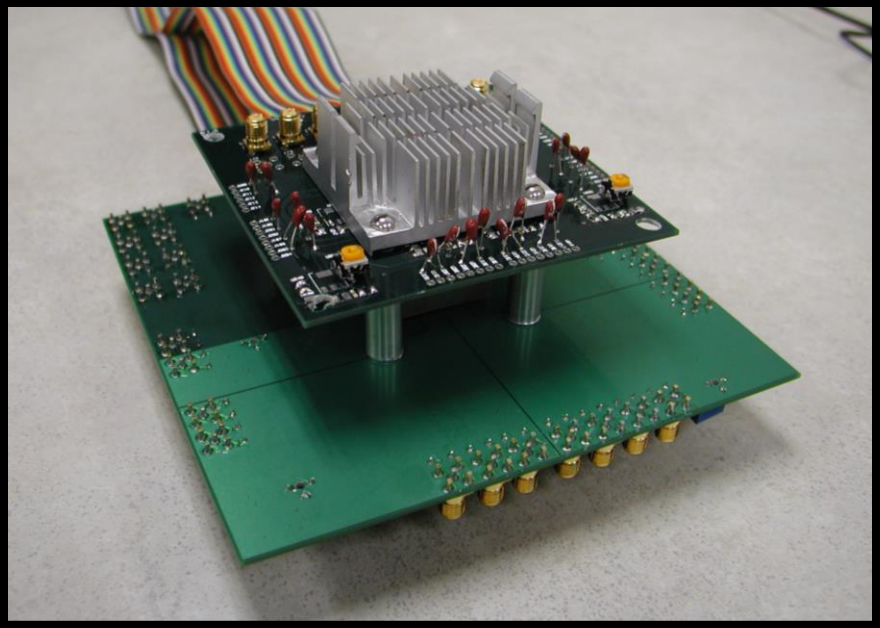


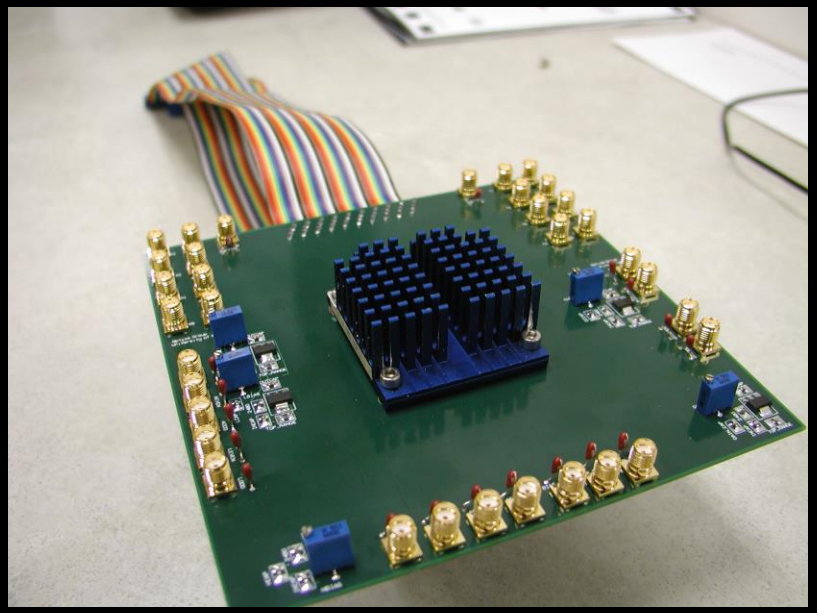
Bottom of SoS chip bump-bonded to PCB



Top of chip showing detector/VCSEL arrays (through PCB cavity)

OE-MCM System



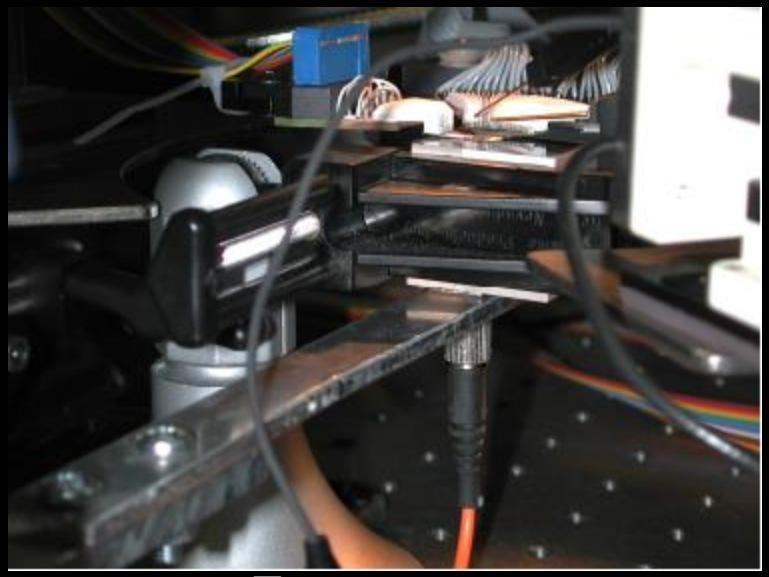


Switch MCM demonstrator

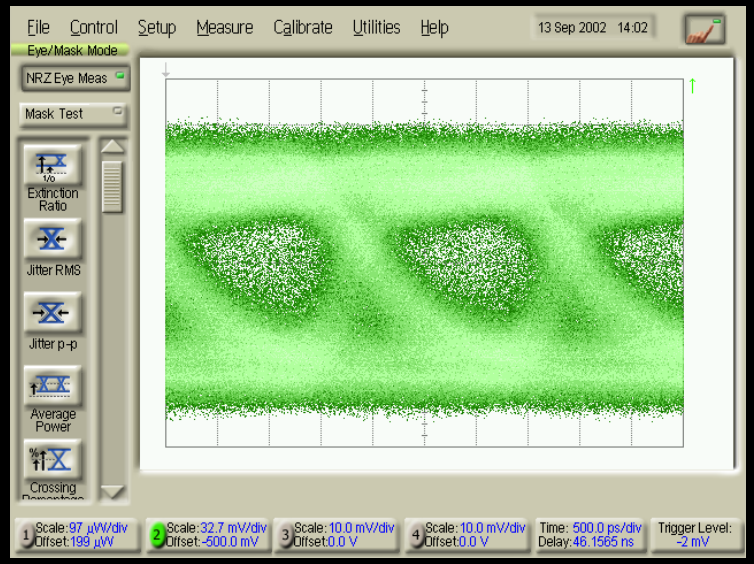
- Large heat sinks are used to dissipate heat from CMOS, VCSELs, and receivers
- Switch is electronically configured through ribbon cables
- SMA cables used for electronic test I/O
- See this at the hardware demo!

Channel Test

- Current results:
  - Optical input coupled to optic from VCSEL
  - Output measured at test pin
  - Single chip/single channel tested at 500MHz
  - Bandwidth limitation due to laser source



Test setup



500 MHz eye diagram

Conclusion and Future Work

- FIG-based OE-MCMs
  - FIG: interconnect medium and structure
  - Tightly integrated and easily manufacturable
- Fabrication and characterization of OE-MCM demonstrator
  - Currently in progress
  - Proof-of-concept for FIG-based OE-MCM technology

Acknowledgements

- Thank you:
  - SoS COOP run
    - UTSi fab run
  - Peregrine Semiconductor
    - Bonding and support
  - Schott Fiber Optics
    - Fiber image guides and support