
Optoelectronic Multi-Chip Module Demonstrator System

Jason D. Bakos, Donald M. Chiarulli, Steven P. Levitan

University of Pittsburgh, USA

Talk Overview

- We present:
 - A novel technology for chip-to-chip optoelectronic interconnection and packaging
 - “Optoelectronic Multi-Chip Modules”
 - Based on *fiber image guides*
 - Our current progress on the fabrication and characterization of a demonstrator prototype
 - Implementation of a 64x64 optical crossbar switch

Talk Overview

■ Outline

□ OE-MCM technology

- Fiber image guide (FIG) technology
- Using FIGs as an interconnect medium
- Silicon-on-sapphire CMOS dies
- OE-MCM fabrication

□ Demonstrator system

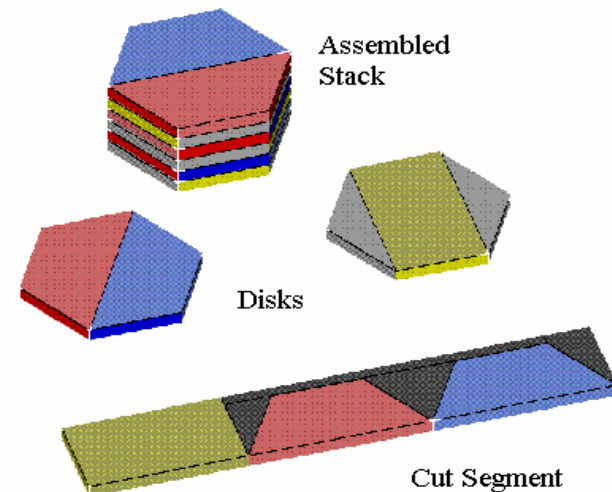
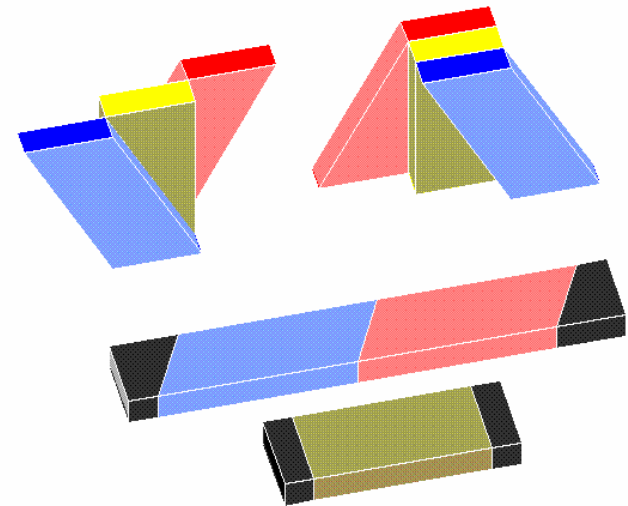
- Architecture
- Interconnection topology
- Chip layout
- Experimental results

Fiber Image Guides

- Dense array of small-core fibers arranged in a lattice
 - Fiber diameter 5-20 μm , pitch 15 μm , 10,000 - 15,000 core/ mm^2
 - (imaging)

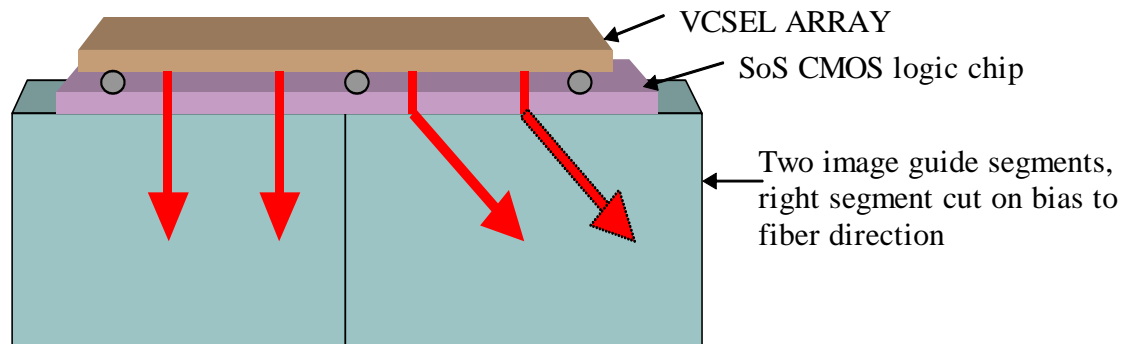
Optical Interconnect

- Optical links
 - Based on rigid fiber image guide segments
 - Acts as transmission medium and structure of MCM
 - Cut image guide at different angles to create horizontal connections between sides of MCM structure
 - Stack image guide segments to create different signaling topologies through MCM



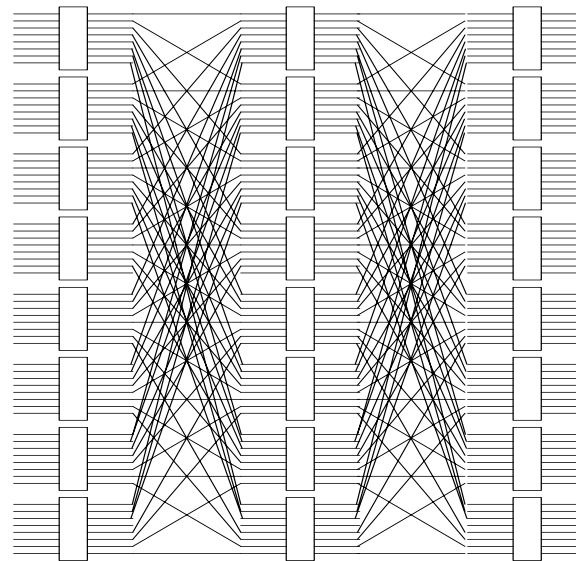
OE Component Design

- Design logic on CMOS with transparent substrate (UTSi)
- Bump-bond SoS die to PCB (electronic I/O)
- Bump-bond VCSEL/detector chips to SoS die
- Bond SoS die to sides of image guide glass



OE-MCM Demonstrator System

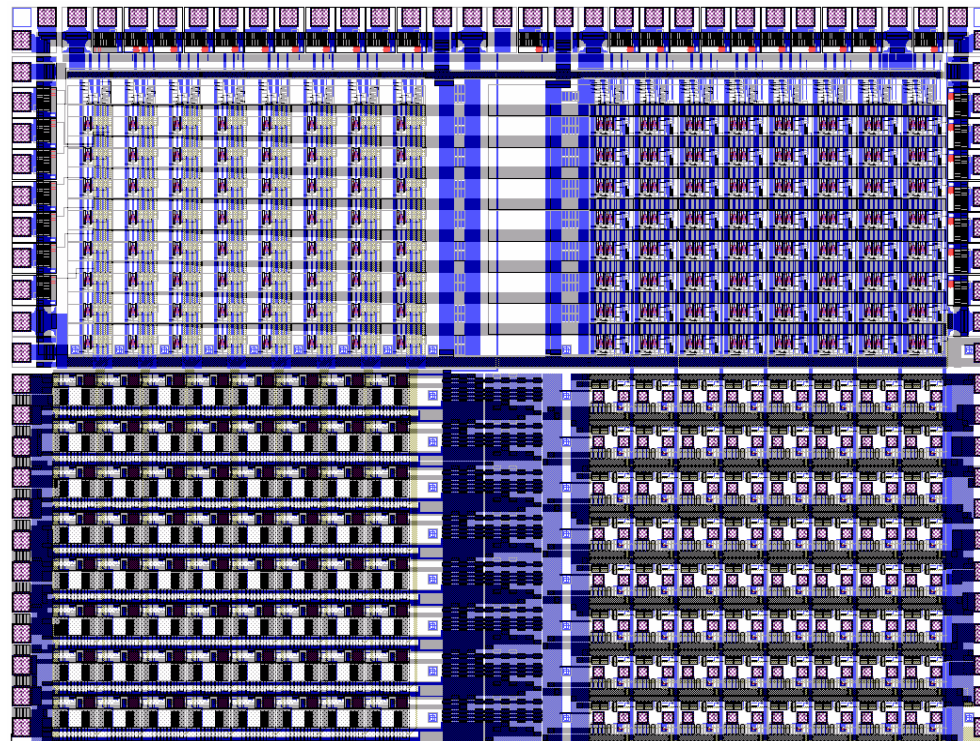
- 3-chip OE-MCM implementing a 64x64 crossbar switch
- Each chip implements eight independent 8x8 switches
- Fiber ribbon cable (8x8) carries optical data in/out of MCM
- Switch is electronically configured
 - 2 level configuration memory



3-stage switch architecture

OE-MCM Demonstrator System

Switching logic and
switch configuration
memory



Receiver section

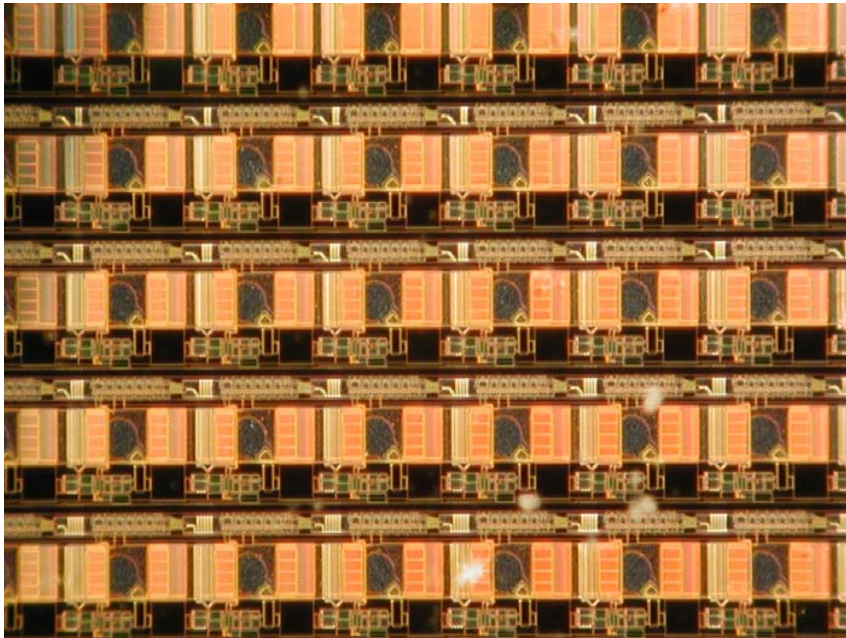
Driver section

Chip layout

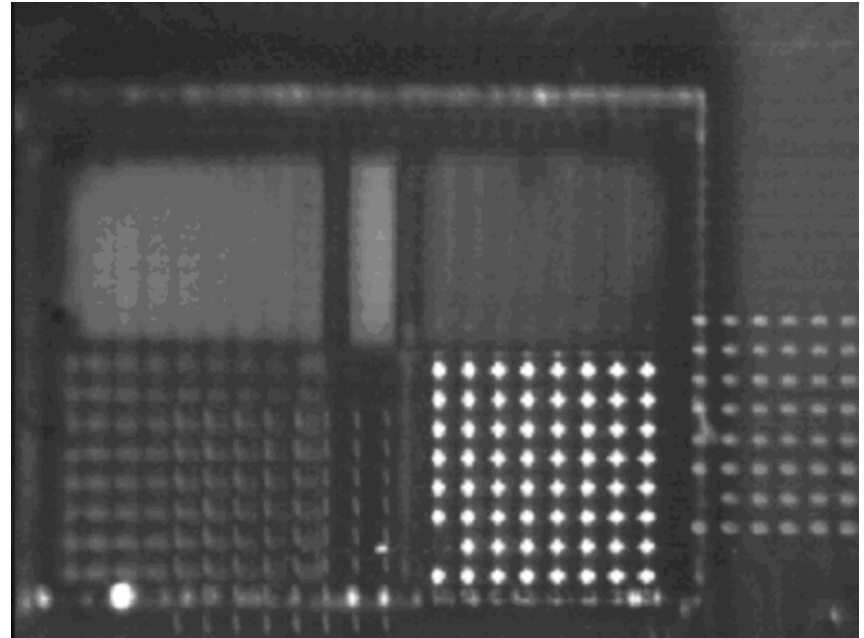
4 x 5.5 mm

Alignment marks

OE-MCM Demonstrator System

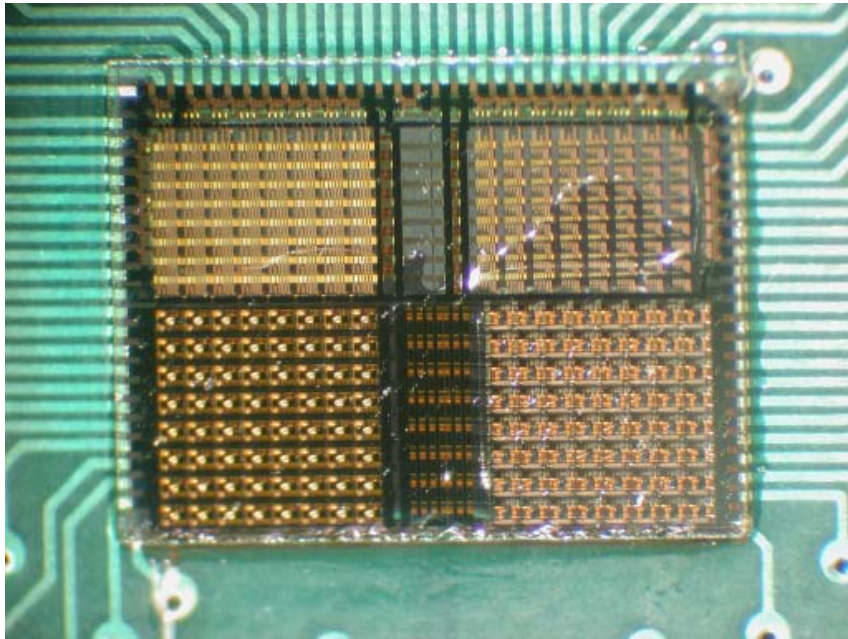


Bottom view of chip showing detectors

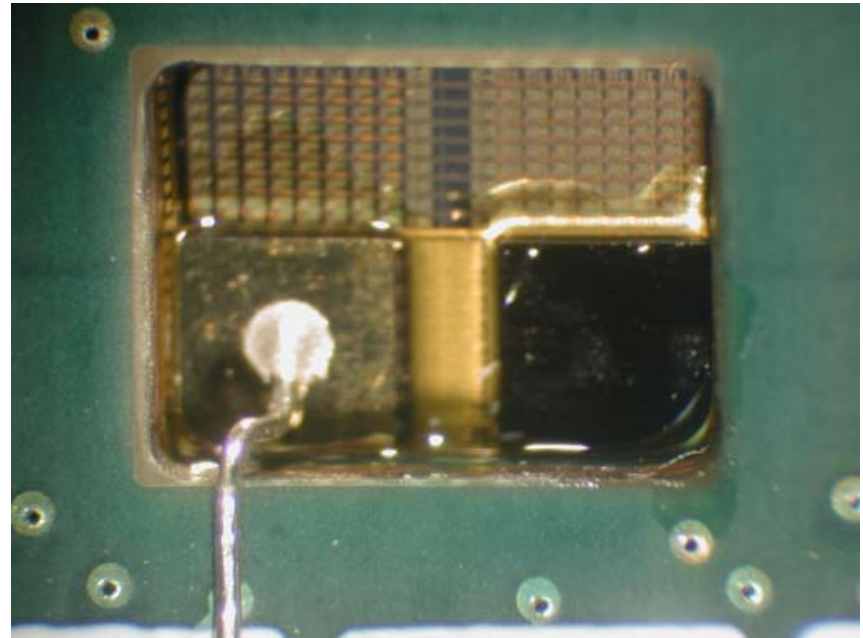


Bottom view of chip showing VCSEL array

OE-MCM Demonstrator System

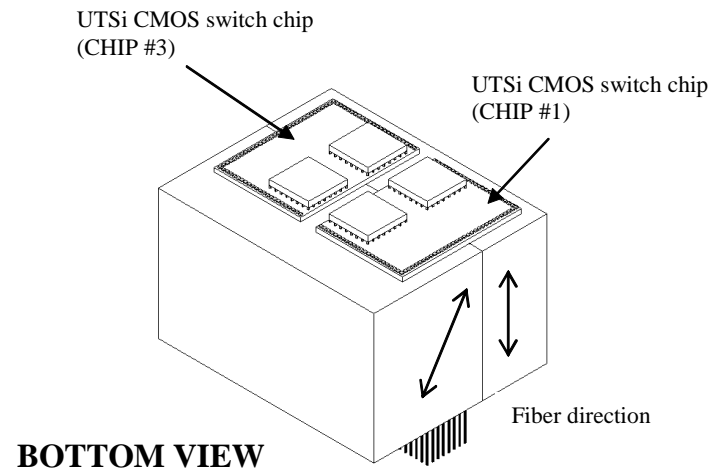
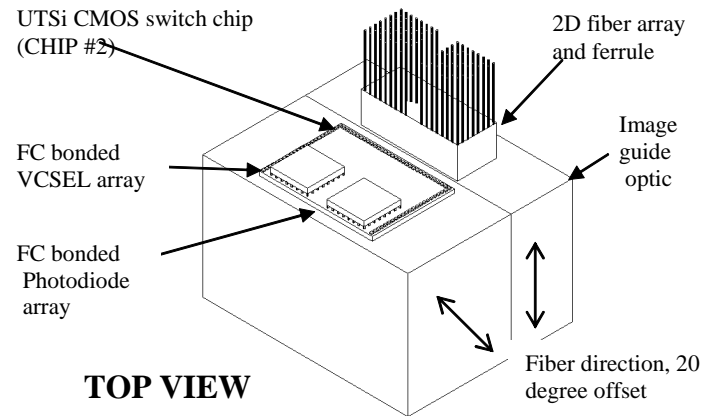


Bottom of SoS chip bump-bonded to PCB



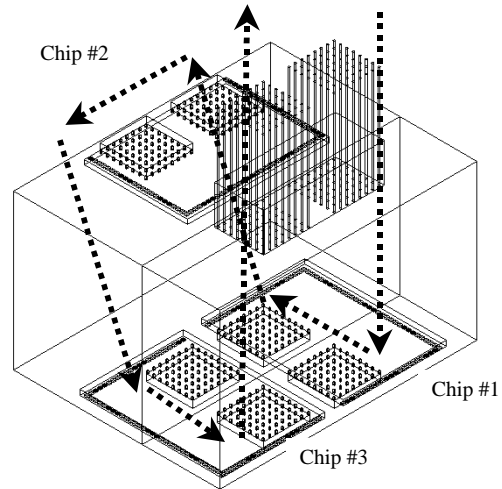
Top of chip showing receiver/VCSEL arrays (through PCB cavity)

OE-MCM Demonstrator System

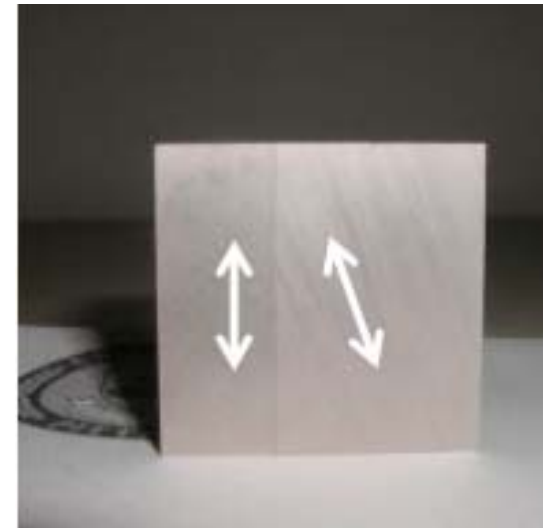
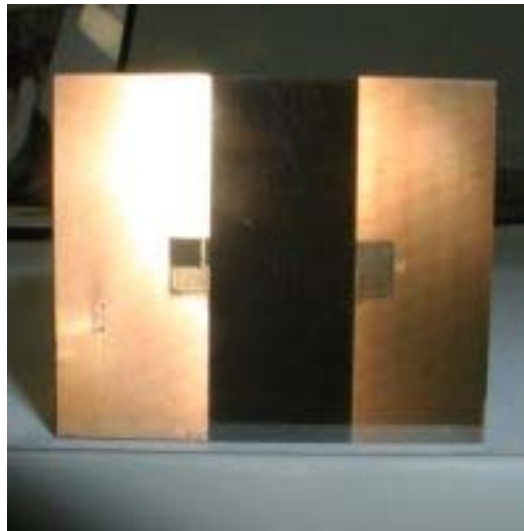
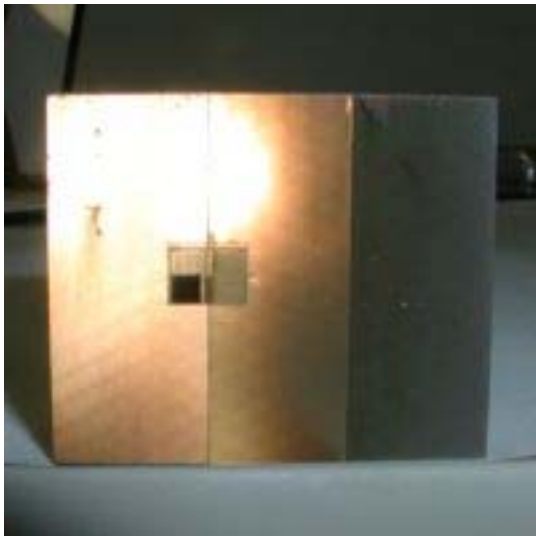


- Image guide offset is required
 - VCSEL/detector arrays not symmetrical relative to chip axis

OE-MCM Demonstrator System



Switch MCM connection topology



Switch chip mounted on fiber bundle structure

OE-MCM Demonstrator System

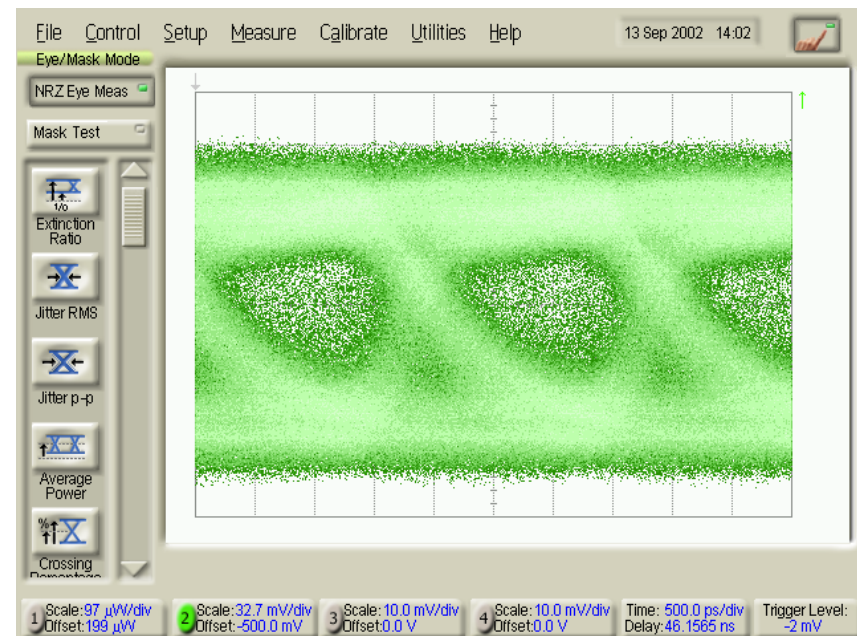


Switch MCM electrical tester

- Switch is electronically configured through ribbon cables
- Large heat sinks are used to dissipate heat from chip and voltage regulators
- SMA cables used for testing

OE-MCM Demonstrator System

- Current results:
 - ❑ Optical I/O coupled to optic
 - ❑ Single chip/single channel tested at 500MHz
 - ❑ Bandwidth limitation due to testing system
 - ❑ Expected throughput: 1-2 GHz/channel



500 MHz eye diagram