

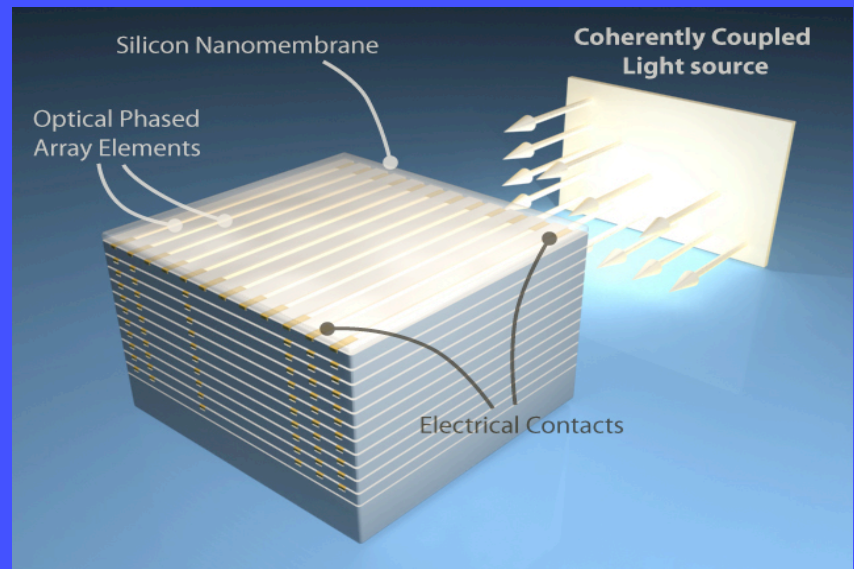
MURI-Center for Silicon Nano-Membranes



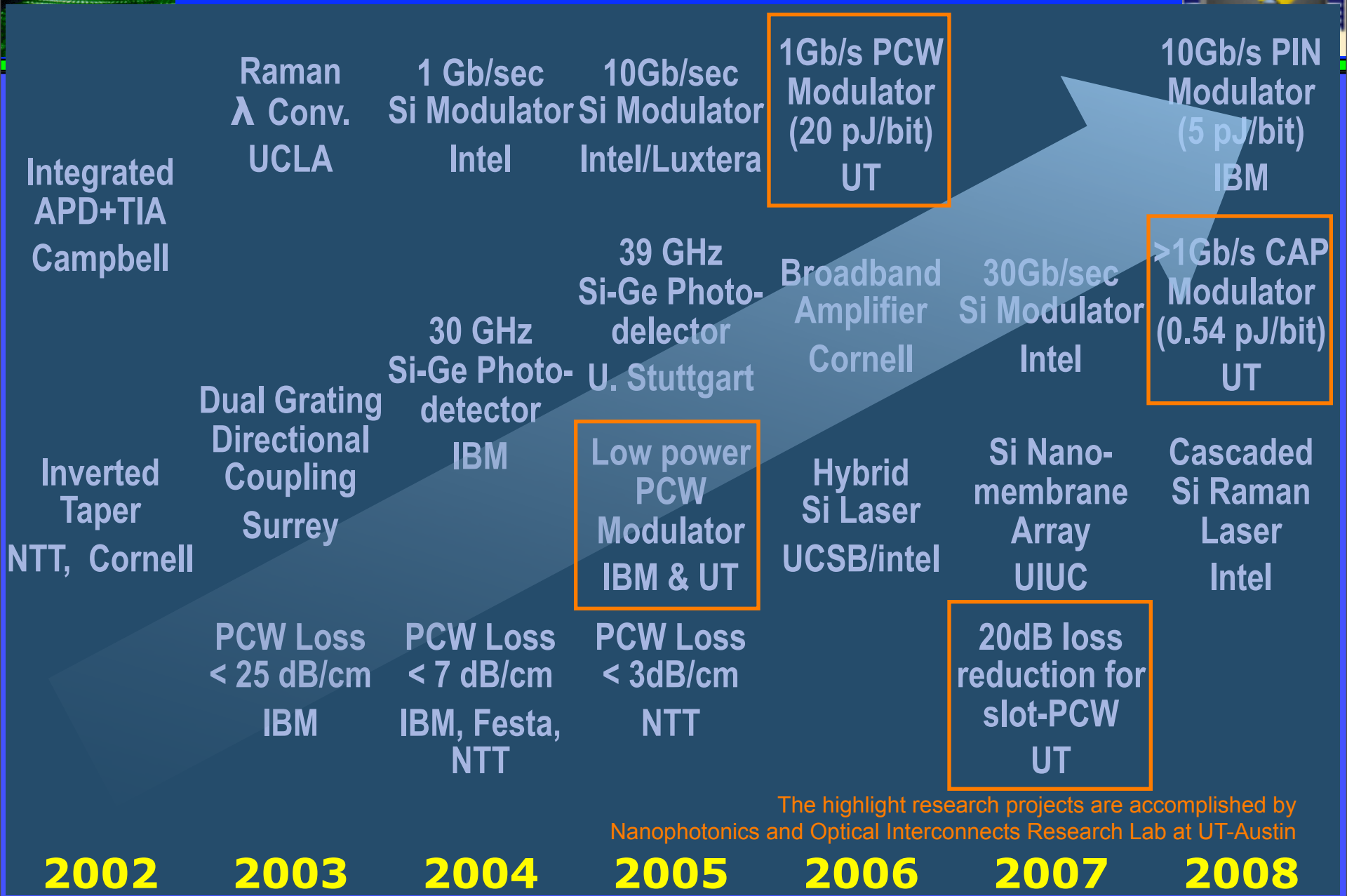
Scientific novelty and Uniqueness:

- **Nanomembrane lithography to form 3D well-aligned silicon nanomembranes**
- **Manufacturable process to form nanowires, photonic crystal waveguides and plasmonic structures on nanomembranes**
- **2D Ultracompact phase locked laser array on silicon as a light source for Optical Phased Array (OPA)**
- **Ultracompact structure provides large steering angles to $\pm 70^\circ$ in both azimuth and elevation directions for Optical Phased Array (OPA)**
- **Slow photon in PCW provides a group index above 300 and provides tunable delay time from 0 to 32 nsecs suitable for phased array antenna applications**

Name of Principal Investigator	School
Ray Chen (Lead)	UT Austin
Seth Bank	UT Austin
Wei Jiang	Rutgers
Fabiab Pease	Stanford
John Rogers	UIUC
Gennady Shvets	UT Austin
Emanuel Tutuc	UT Austin

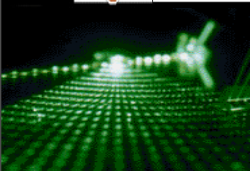


Progress of Silicon Nanophotonics



The highlight research projects are accomplished by Nanophotonics and Optical Interconnects Research Lab at UT-Austin

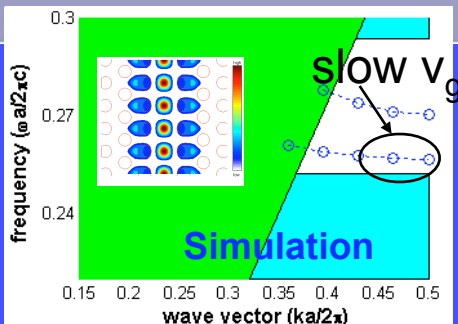
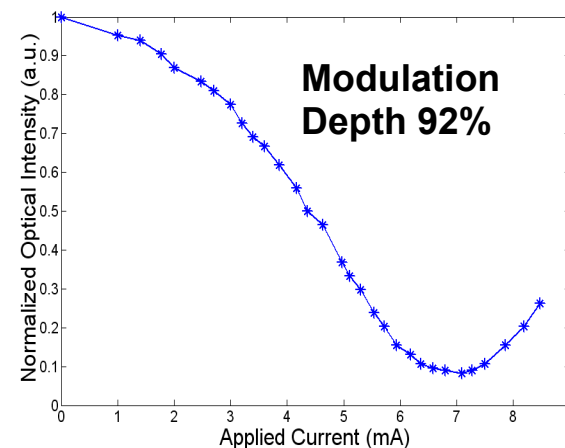
Gigahertz *p-i-n* Diode Embedded Silicon Photonic Crystal Mach Zehnder Interferometer (MZI) Modulator



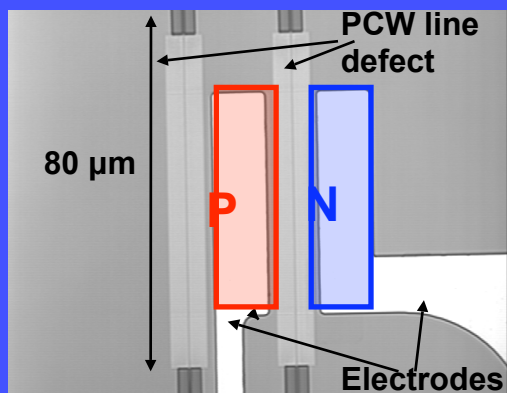
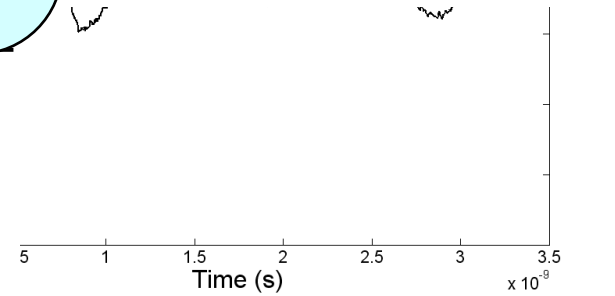
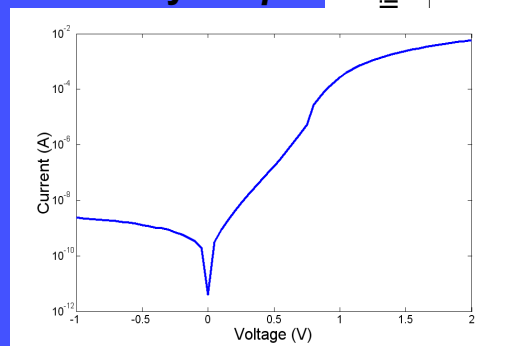
Optical Performance

Key features

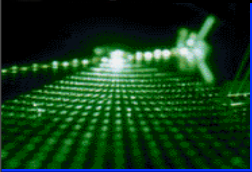
- Slow light in Photonic Crystal Waveguide (PCW) to enhance modulation by up to 40X
- Unique electrode routing for on-chip integration with driver
- Faster speed due to the enhancement of injection current density by downscaling the device size



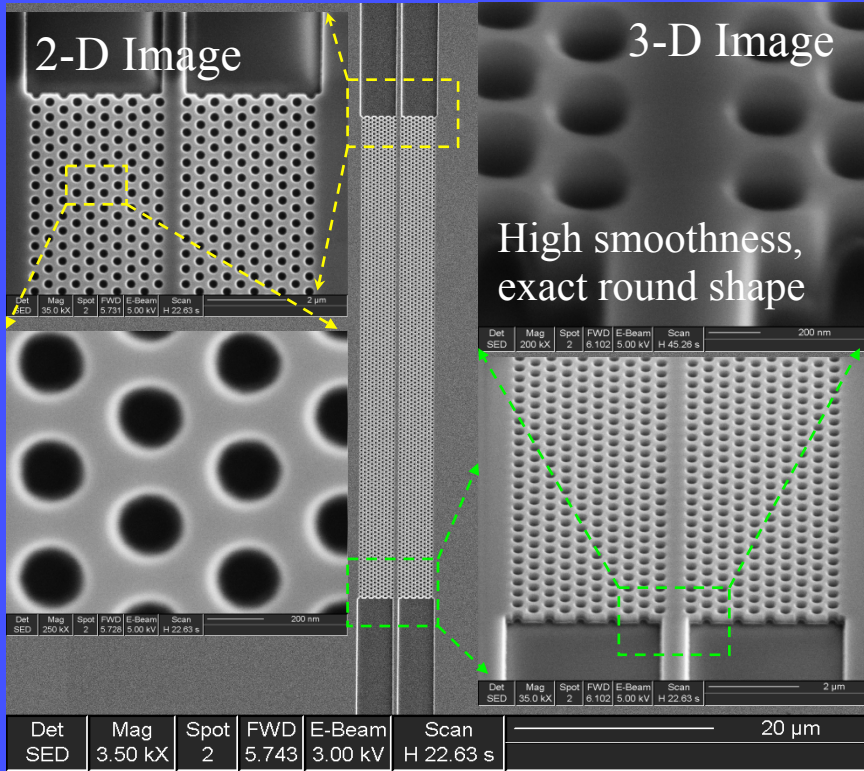
I-V curve of photonic crystal *p-i-n* diode



Lanlan Gu, W. Jiang, X. Chen, L. Wang, and R. T. Chen "High speed silicon photonic crystal waveguide modulator for low voltage application," *Applied Physics Letters*, 90, 071105 (2007).



SEM Micrographs & Key Facilities



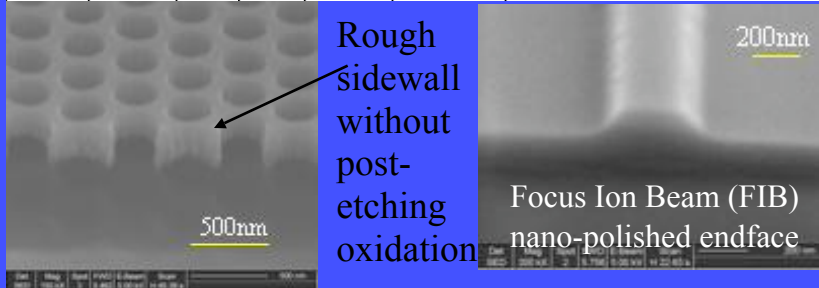
3-D Image

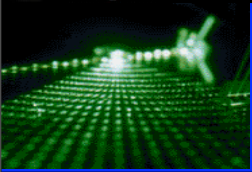
2-D Image

High smoothness,
exact round shape

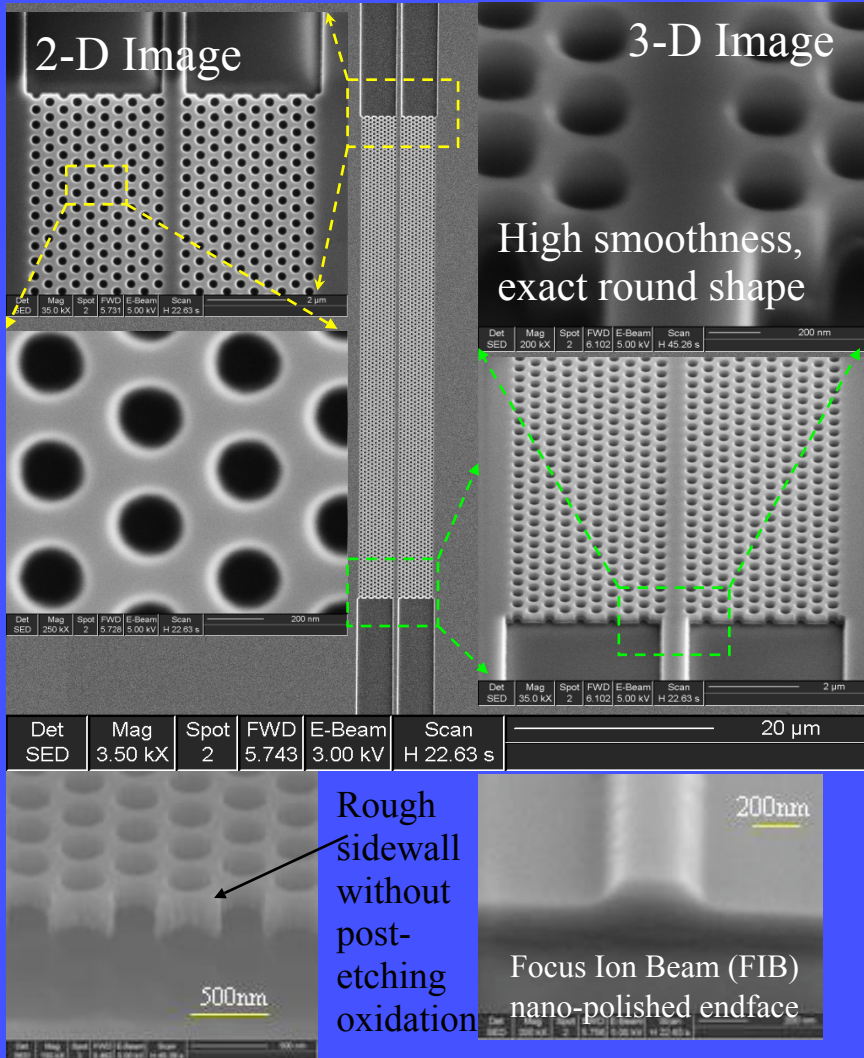
Rough
sidewall
without
post-
etching
oxidation

Focus Ion Beam (FIB)
nano-polished endface

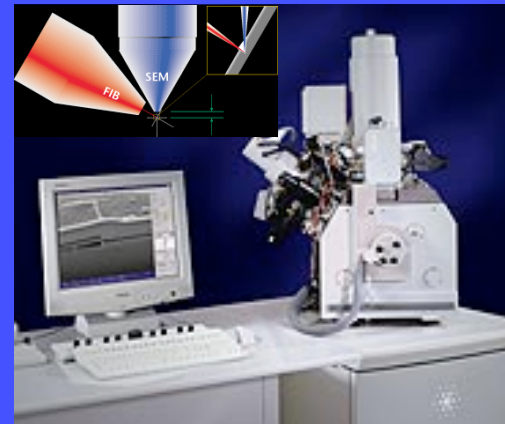




SEM Micrographs & Key Facilities



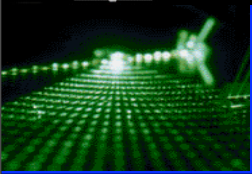
JEOL JBX-6000FS/E E-Beam Nano-Lithography



FEI Strata DB235
Dual Beam SEM/FIB
Nano-characterization System



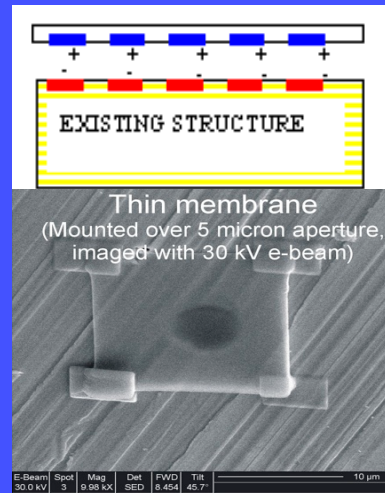
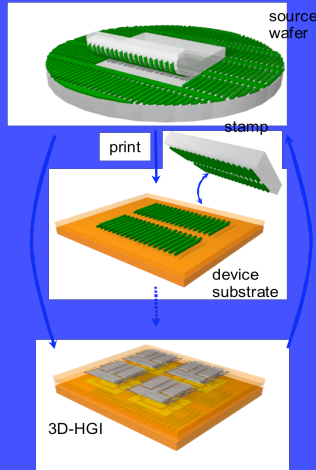
Plasma-Therm 790 Si
and SiO₂ Reactive
Ion Etching (RIE)



Detailed Approaches



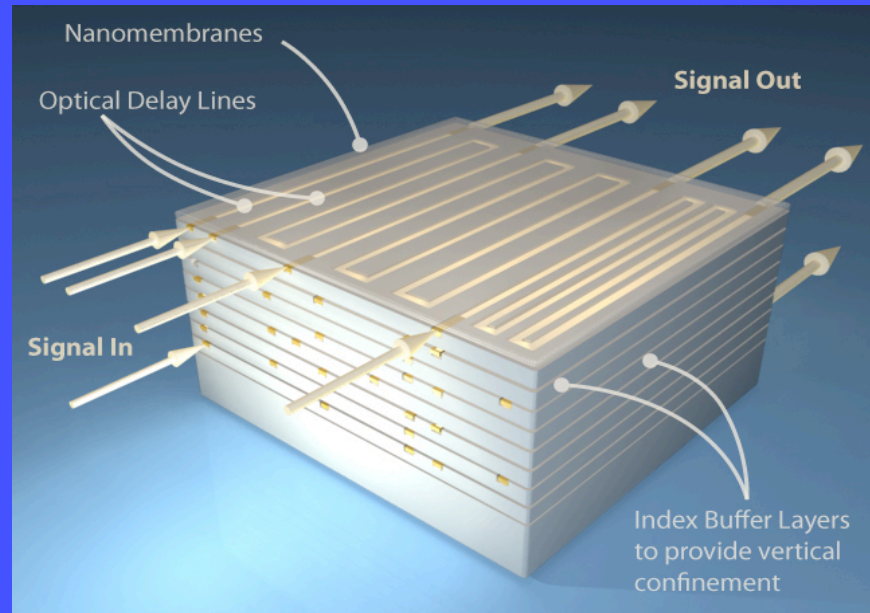
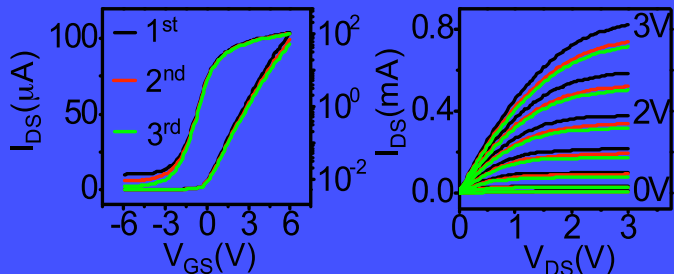
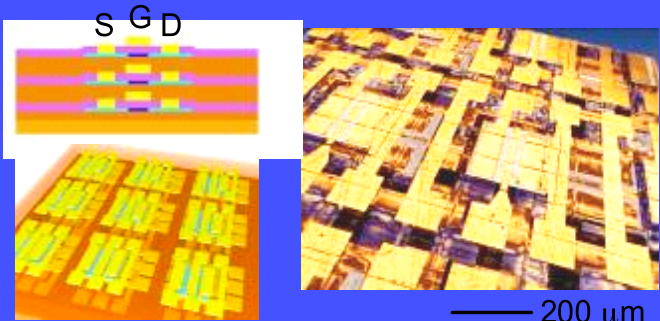
← Transfer printing of nanomembranes that contain nanostructured waveguides
 ↓ Demonstrated 3-layer devices

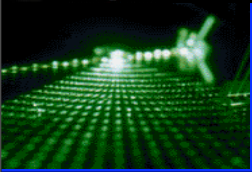


← Use electrostatic forces to align 3D membrane stack to a small fraction of a micron. Many variations are possible:

- An interfacial fluid layer to allow lateral motion
- A Langmuir-Blodgett trough is already installed for the deposition of mono- & oligo-layers.

← thin (<100nm) sliver of crystalline diamond made by FIB. Then the FIB then 'tacked' it into place again using deposition of Pt to provide the tacks

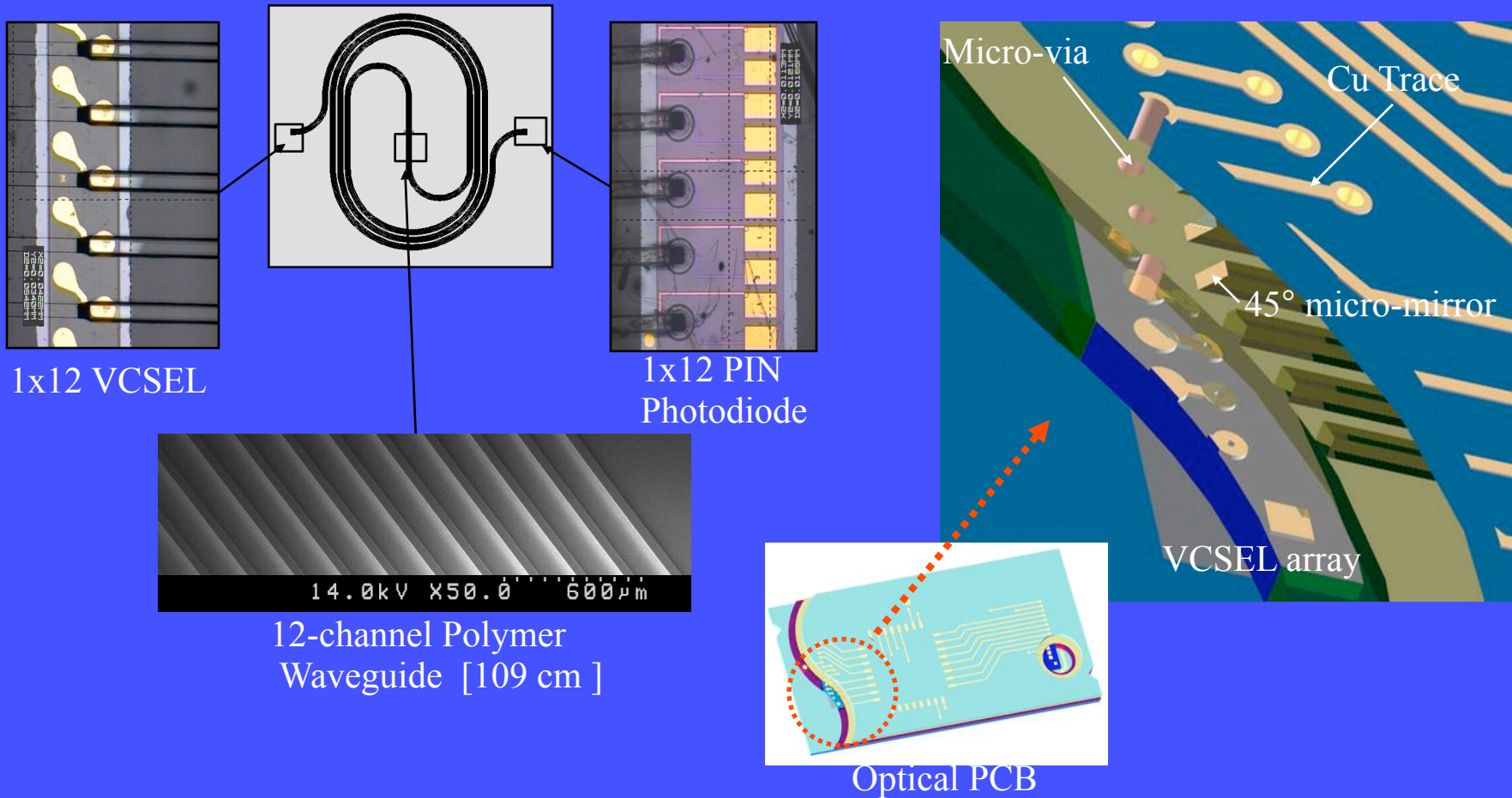




Fully Embedded Board Level Optical Interconnection



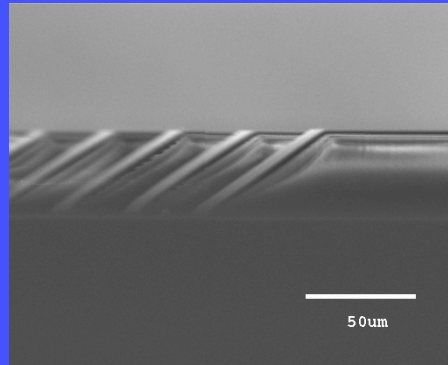
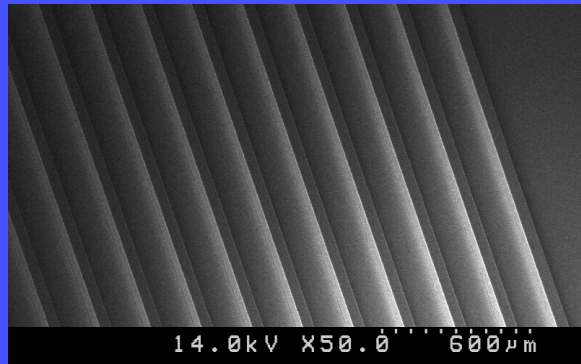
- *Unique Architecture for Optical PWB (Printed Writing Board)*
; All the optical components are interposed inside the PCB
Solve the package problem / Reduce Cost Effects



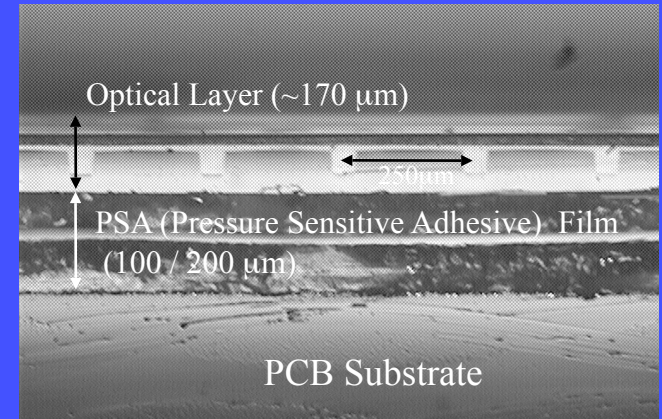
Lamination of Optical Waveguide Film & Integration of Thin Film VCSEL



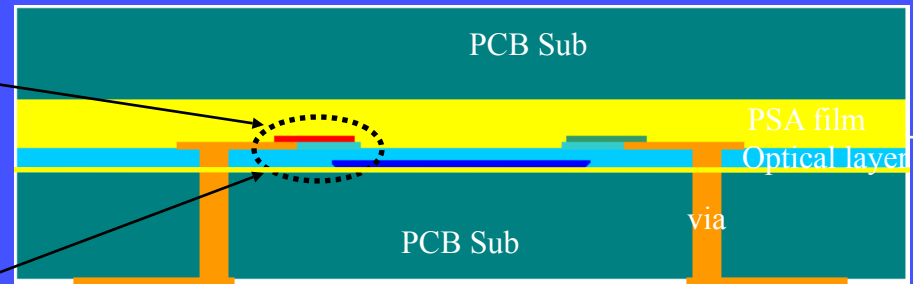
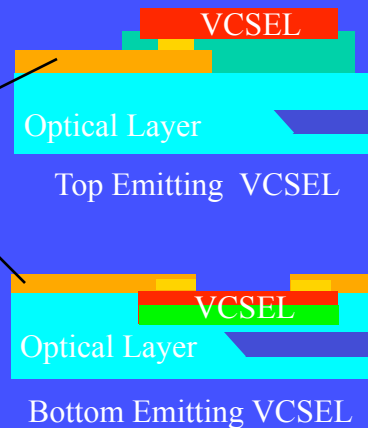
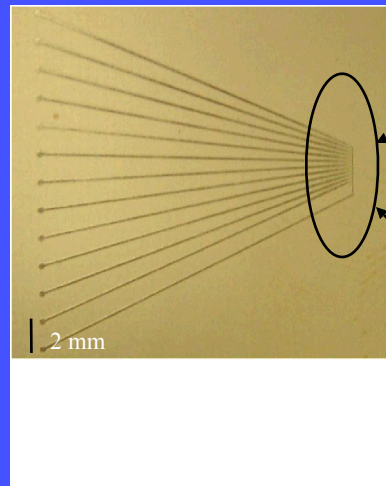
➤ 12-Channel Polymer Waveguide & 45° Micro-Mirror



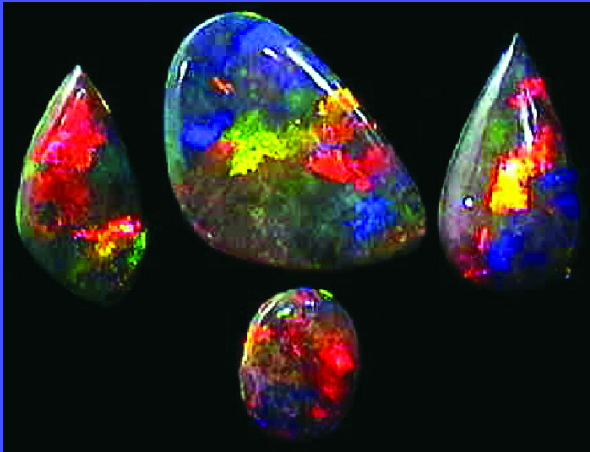
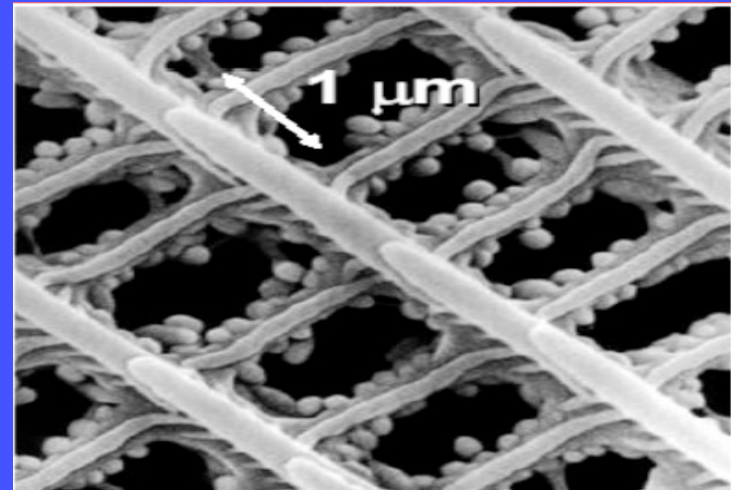
➤ Cross Section View of Laminated Optical Layer



➤ Cu Transmission Lines for VCSEL (or PD) Integration



- PSA (Pressure Sensitive Adhesive) Film : 100 / 200 μm
- Optical Waveguide Film Layer = ~ 170 μm



Opal, the best known periodical structure in nature.

