Technology Transfer at UC-Santa Barbara
[for successful start-ups]

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Start-Ups: Some Context

- University technology is early stage (embryonic, even)
  - A lot of risk in developing products
- Established companies prefer relatively "de-risked" opportunities
  - Challenging to find interested established companies if technology needs significant investment
- Startups, formed specifically to further develop one key technology, can fill that gap very effectively – or continue to expand into a mature, long-term company

And while they are doing it….

- Create jobs
- Attract funding to region
- And if they are lucky…
  become the next Google??

CALIENT 3D MEMS

ASYLUM RESEARCH

expertcity.com

AGILITY

Soraa

KONARKA

transphorm

FLUENCY LIGHTING TECHNOLOGIES

aurrion

SLDLASER

UNIAX POLYMER ELECTRONICS

UCSB Start Up History

- 1989: Digital Instruments (atomic force microscope), acquired by Veeco Instruments (now Bruker Instruments)
  - Digital Instruments' spin-off, Asylum Research, formed in 1999
- 1989: *Computer Motion, Inc (robotic surgery) , acquired by Intuitive Surgical
- 1990: Uniax (organic LEDs), acquired by DuPont
- 1992: Optical Concepts (VCSELs), acquired by W.L. Gore
- 1994: *Software.Com/Openwave (Internet messaging) → *Sonos*
- 1995: Terabit Technologies (InGaAs/Si APDs), acquired by Ciena
- 1996: *Indigo Systems (IR imaging)
- 1996: Nitres (GaN LED lighting), acquired by Cree
- 1998: Agility (widely-tunable lasers), acquired by JDS Uniphase
- 1998: Expertcity/Citrix Online
- 2000: *Calient Networks (photonic switching), acquired by Suzhou Chunxing Prec. Mech.
- 2003: Aerius Photonics (VCSELs, SBIRs, IR imaging, etc.), acquired by FLIR
- 2008: Aurrion (InGaAsP/SOI—Int. Silicon Photonics), acquired by Juniper Networks
- 2008: *Freedom Photonics (1300nm tunables, SBIRs, etc.)

All of these companies maintain a footprint in Santa Barbara.
Many of these have early entrepreneurs who are still actively building second- and third-generation start-up companies from technology developed at UCSB.

*Not a direct spin out of UCSB technology

Entrepreneurial Engineering at UCSB

+ 230 companies started from campus

Average of 14 companies formed every year

UC SANTA BARBARA
College of Engineering

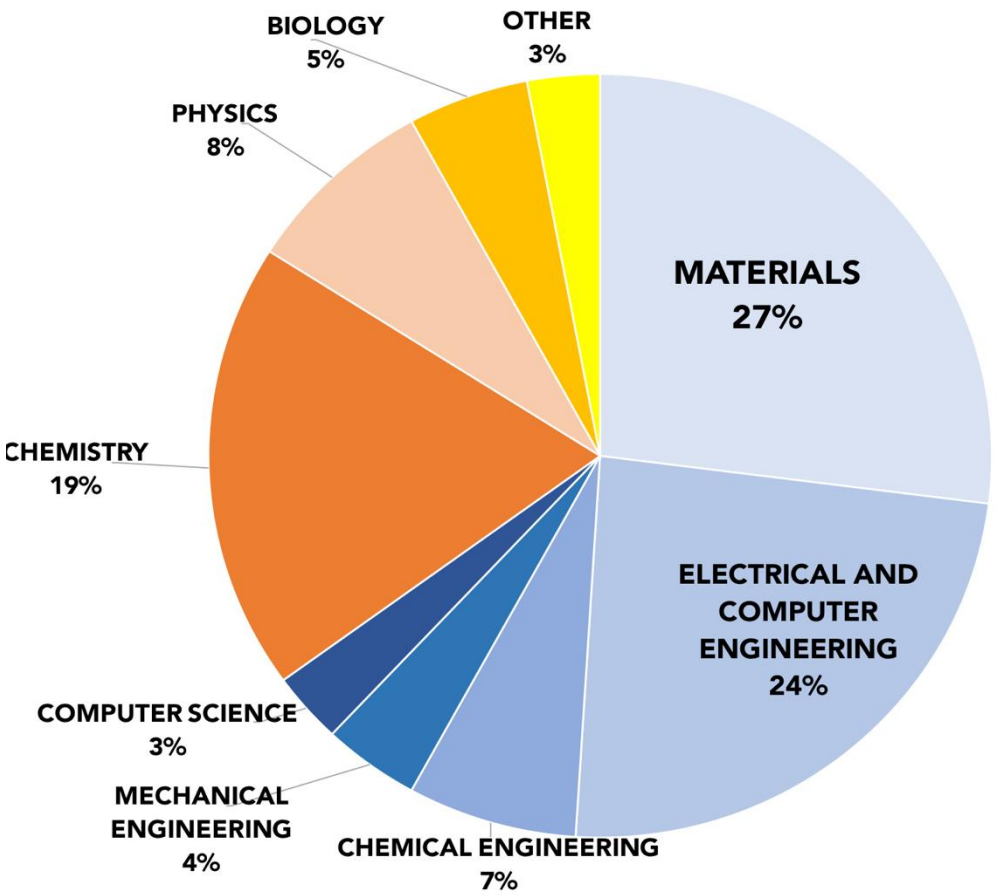
The Economic Impact of Start-Ups

- According to recent research, UCSB tech start-ups raised $53M in 2017 and $124M in 2018 (to-date) from angels and VCs.

- Recent Successful Startup Exits:
  - August, 2016: Aurrion – Acquired by Juniper Systems ($165M)
  - July, 2016: ShadowMaps – Acquired by Uber
  - October, 2016: CytomX IPO (currently trading at approx. $23)
  - February, 2014: Inogen IPO (currently trading at approx. $247)
  - December, 2014: Eucalyptus – Acquired by Hewlett Packard
  - December, 2012: Asylum Research – Acquired by Oxford Instruments ($80M)
  - August, 2012 Sirigen – Acquired by Becton Dickinson ($90M)

FY18 TIA Portfolio Activity for UCSB

IPC 2019



Invention Portfolio

90 New in FY18

- 664 Active Inventions
- 474 Active US Patents*

**Inventions can be subject to more than one patent*

- 261 Active Foreign Patents

License Agreements

37 New in FY18

- 134 Active

65% of New Invention Portfolio Involves CoE

Industry IP Rights to Funded University Research

IPC 2019

Typical Situation (small funding levels):

- Industry request (Existing large company)
  - Royalty-free license to all inventions generated in project
- University position
  - Depending upon funding level, provide right of first refusal to obtain a non-exclusive, royalty-bearing license
  - Filing and maintenance costs to be born by licensee and fair and reasonable royalties to be negotiated, based upon value of invention
  - Preferential exclusive licenses may also be negotiated at fair and reasonable terms; if not desired, non-exclusive licenses to other parties may be negotiated with up-front fees required

For larger funding levels (where all project costs are covered):

- More favorable pre-negotiated IP terms can be obtained

Why Technology Transfer to Start-ups?

- Move useful advances into the private sector
  - Why not just publish and let existing companies select what they want?
    - Professional pride may inhibit process in companies
    - Start-up costs in companies compete with existing priorities
    - Inventors (from universities) more driven to make ideas succeed
    - Start-ups more willing to license IP, because they need protection
    - Start-ups may be best avenue to mature IP with Angel, VC or government funding. Then, companies can decide what to select (acquire) after start-up proves feasibility (or not)

- Fulfills a primary role of a University
  - Technology developed benefits society
  - Rewards faculty and student entrepreneurs (attracts/retains/supplies quality)
  - Provides resources to enable further teaching and research
    - (Indirectly→ SBIRs, gifts, etc.; supports university facility costs. A modest percentage of patent royalties are returned to departments)

How to do it (if at University)

- Keep a good lab notebook (regardless)
- Educate yourself in Entrepreneurism (TMP @ UCSB)
- When your viable idea for a high-demand product occurs:
  - Submit all University developed IP to University IP office (TIA)
  - Develop plan to create product: who are customers; how to market; what team is required; what resources are needed; timeline; how costly; how to finance
  - Find separate space/facility to work and develop new company IP
  - Look into finance options—SBIRs; Angel investors, friends and family, VCs
  - License University IP if desirable
  - Manage costs: e.g., outsource expensive fabrication costs
  - Select quality team members, and only those needed

Entrepreneurism:

UCSB Technology Management Program

TECHNOLOGY MANAGEMENT
UC SANTA BARBARA

New Venture Competition:

TMP's flagship entrepreneurial program

NVC
UC Santa Barbara

Established 2001

Campus-wide, year-long

Transformative Educational Experience

Strong Network of Mentors and Advisors

Track Record of Successful Startups

TMP Academic Programs:

- Technology Management Certificate (for current undergraduate students)
- Graduate Program in Management Practice Certificate (for current graduate students)
- Master of Technology Management (professional masters degree)
- PhD in Technology Management

Student Entrepreneur Success Stories

inogen

- *Winner 2001 NVC*
- *2014 IPO*
- *Market value$2.5 B*

APEEL SCIENCES™

- *Winner 2012 NVC*
- *$70M+ capital raised*

TrackR

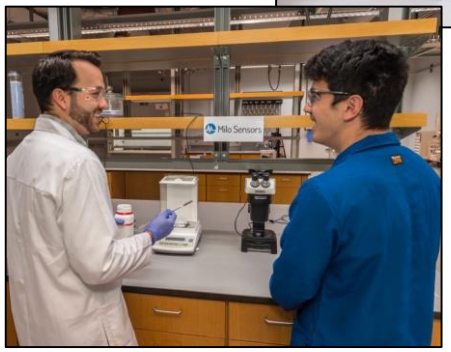
- *Winner 2009 NVC*
- *$63M capital raised*
- *Revenue $50M-$100M*

Sirigen

- *Winner 2003 NVC*
- *Acquired by BD, 2012*

Find separate space/facility:

CNSI Technology Incubator – Laboratory Resource for Startups



- Mission – Bring scientific and technological innovation into the **economy** and society
  - 900 sq. ft. of wet-lab / dry-lab space set aside for Incubator
  - Collaboration with UCSB I&E Ecosystem
- Eligibility
  - Active corporate licensees of UCSB intellectual property
  - Companies founded by UCSB faculty, staff, or students
  - Local pre-production community start-ups

Milo Sensors

NVC Tech Finalist Soilight

(Incubator prize, Summer 2018)

bioProtonics

Laxmi Therapeutic Devices

Fluency Lighting Technologies

Nexus Photonics

Current residents

Mentium Technologies

NEXT Next Energy Technologies, Inc

Apeel Sciences

Former members

Outsource expensive fabrication/testing:

UCSB Shared Facilities

Nanotech Labs

MRL Labs

47 Facilities

304 Instruments

Part of what makes UCSB - and Santa Barbara in general - a good place to start a company

Nanotech Facility Overview

UCSB

- **~12,000 sq. ft. of cleanroom space (class 1000, 100)**
- **Full set of nanofabrication tools for thin film patterning, deposition, etching, integration, modification, characterization, metrology**
- **~$50M of fabrication equipment (replacement cost)**
- **Operates as a highly accessible user facility**
- **Highly skilled staff for supporting process development, tool training, maintenance**
- **~ $6M/yr in yearly recharges. ~$4M/yr from industrial use ($3.5M small company)**
- **No State subsidy for the facility. Runs on recharges only.**

Main corridor for access to 7 Bays/6 Chases

Bay 3
Class 1,000 – Deposition

Bay 6
Class 100 – Lithography

www.nanotech.ucsb.edu

Nanofabrication Equipment - Overview

- **Lithography**– Steppers (i-line(2) and **DUV**), **EBL**, Contact, Nanoimprint
- **Etching** – **ICP**(3), **CAIBE**, RIE(3), SiDRIE, vaporHF, XeF_2, CMP

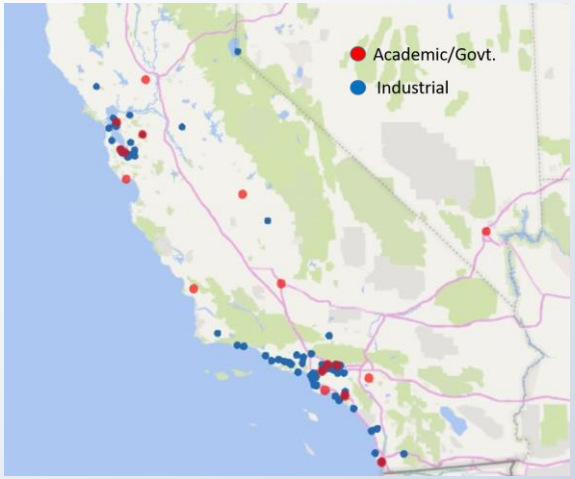
ASML-DUV-248nm
Only 3 at Universities
Sub-200nm Full Wafers
Si-Photonics
Quantum Computing

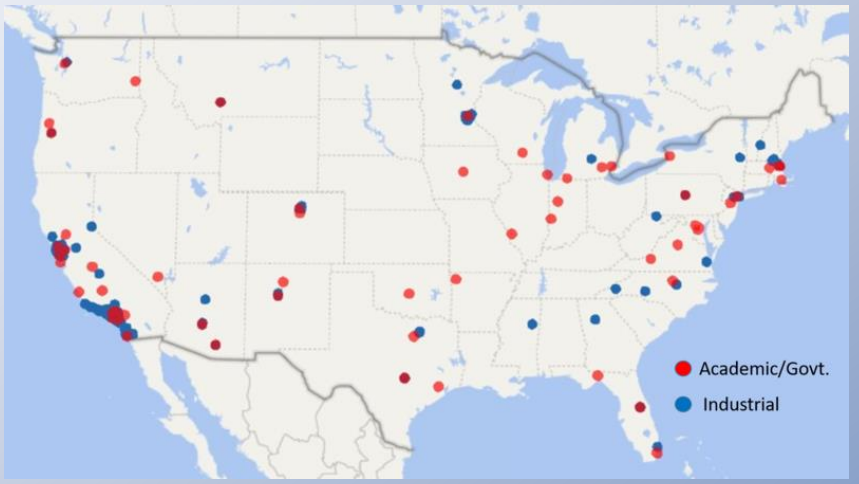
JEOL 6300 EBL
Sub-10nm Patterning
<5nm Stitching errors
Full Wafers
THz electronics
Advanced Photonics

Panasonic ICP Etcher/Asher
Dielectrics, Metals, Semiconductors
Workhorse systems – often >18 Hrs/fday
nm-scale control - reproducible

A Proven State and National Resource:

Map of Institutions Served 2006-2018





- **Regional (CA) Reach**
  - **185 in state external industrial institutions** (and 18 Academic)
  - Includes: Google, HP, Apple, Raytheon, Lockheed Martin, Cree, JDSU, Juniper Networks, Bruker, HRL, Teledyne, Northrop Grumman, Intel, KLA-Tencor, JPL, Tyco, Dupont, FLIR, Myriads of small and start-up companies
  - **46 SB/Goleta Area**
- **National Reach**
  - 58 out-of-state External Industrial Institutions out of state
  - 41 External Academic Institutions out of state

105 Companies Over Last 2 Years

Fluency Lighting
Nexus Photonics
Ultra-low Loss Technologies
3DCD
Applied Materials
Bruker Metrology
Continental Advanced Lidar Solutions, Inc
Corning Technology Center
Cree
Facebook Technologies, LLC
FLIR Commercial Systems
FLIR EOC
Garmin International, Inc.
General Atomics
Google Inc.
HP Labs
Hughes Research Laboratories
Infinera
Juniper Networks
KLA-Tencor Inc
Lam Research Corporation
Lockheed Martin, Missiles & Fire Control
Raytheon Vision Systems
Space Exploration Technology Corp.
SRI International
Technicolor HES
Teledyne Scientific & Imaging
The Aerospace Corporation
Toyon Research Corporation
3D-Sensir Inc (Acqubit)
AdTech Photonics
Advanced Modular Systems
Advanced Nanostructures
AdvR
Aeonian Semiconductor Technology
AISthesis Products, Inc.
Angstrom Science
Apic Corporation
Applied Nano
Applied Nanostructures, Inc
Aptitude Medical Systems Inc
Astrileux Corporation
Asylum Research
Attollo Engineering, LLC
Ayar Labs
Calient Networks
CBrite
Christian Gutleben
Complete Genomics Inc.
Crossbar Inc.
Crystalline Mirror Solutions LLC
Crystalline Mirrors (Vixar)
Drinksavvy Inc.
Duet Microelectronics
ELR Systems LLC
Freedom Photonics, LLC
Genapsys Inc
GenXComm Inc
Ideal Power Inc
Innovative Micro Technology
InnovativeIII-V.Solutions
Laser Components DG Inc
Laxense, Inc.
Laxmi Therapeutic Devices
Magic Leap
Milo Sensors Inc.
Momentum Optics, LLC
Nano Precision Medical
Numerical Design, Inc.
Omniome, Inc.
Owl Biomedical Inc.
Parthian Energy
Pendar Technologies
PiMEMS Inc.
Praevium Research
Promerus LLC
QmagiQ
RLC Solutions
Rodman Scientific
Royole Corporation
Sensor Creations
SensorMetrix
Sientra Inc
Silicon Designs, Inc.
Solar Junction Corporation
Solution Deposition Systems
Soraa Laser Diode, Inc
Soraa, Inc.
Spectradyne LLC
SurForce Corporation
TelAztec
Terray Therapeutics
Transphorm
Tribogenics
Ultima Genomics
VoxtelNano
Westar Automation LLC
Xerical Sciences
Zephyr Photonics

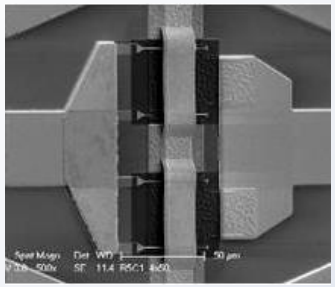
UC SANTA BARBARA engineering

Project Sampling from UCSB Nanofab Users

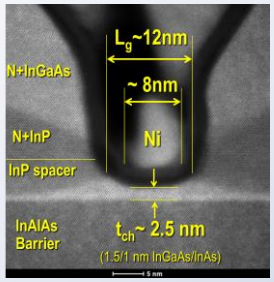
The convergence of research and innovation.

Electronics, Photonics, MEMs, Microfluidics, Materials, Physics

GaN HEMTs

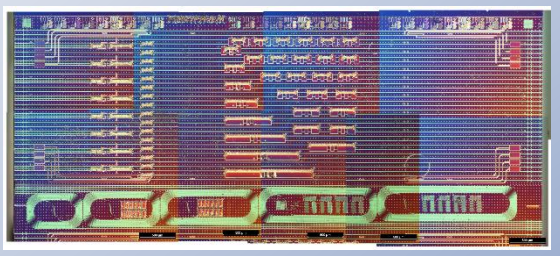


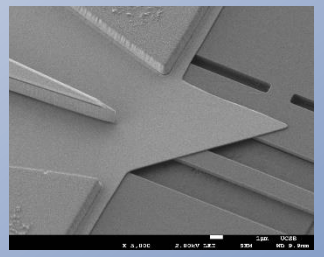
III-V MOS



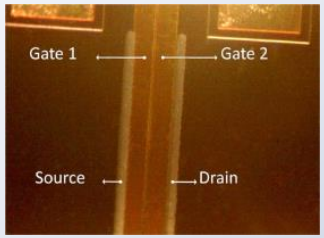
LEDs for Lighting

Si photonics
Heterogeneous III-V Si Integration

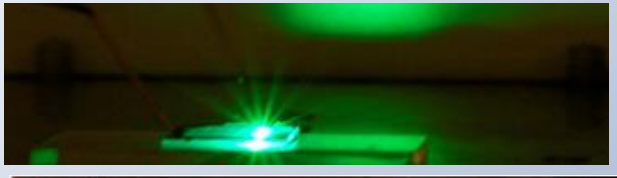


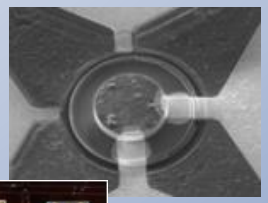


Organic FETs



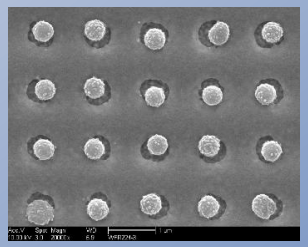
Nitride-based lasers

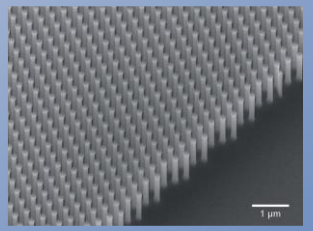




VCSELs

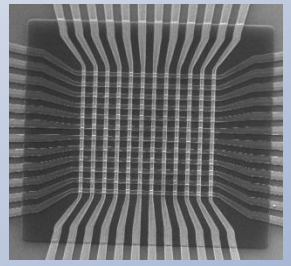
DNA Sequencing





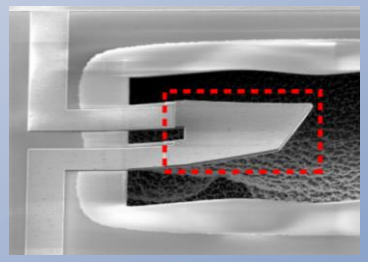
Chem Sensing

THz transistors

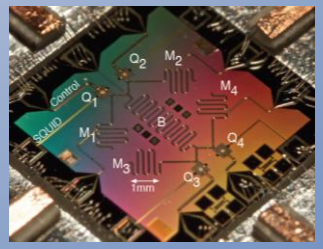


Phase-change memory

InP-Photonic ICs

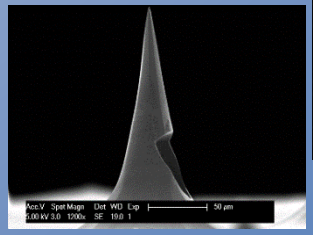


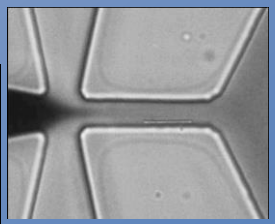
Quantum MEMs



Q-bits

Microneedles





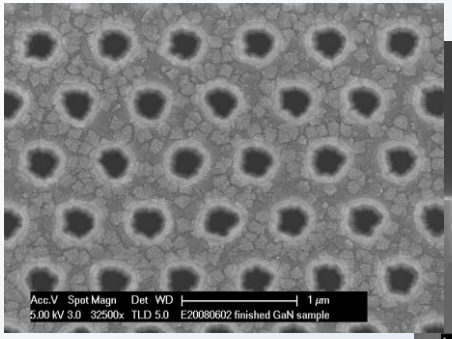
Micro-Nanofluidics

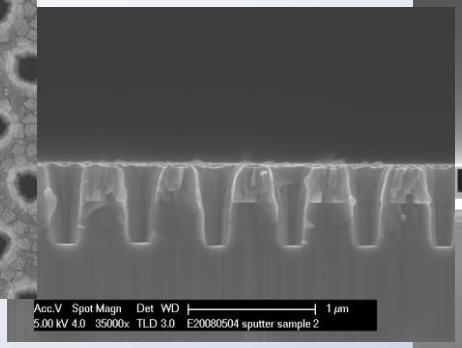
Solid-State Lighting, Photovoltaics, Thermoelectrics, Oxide Electronics

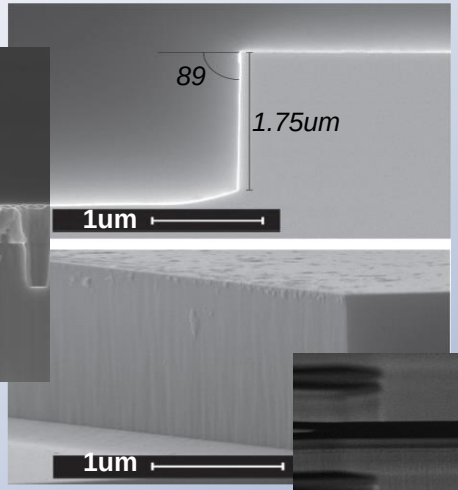
UCSB

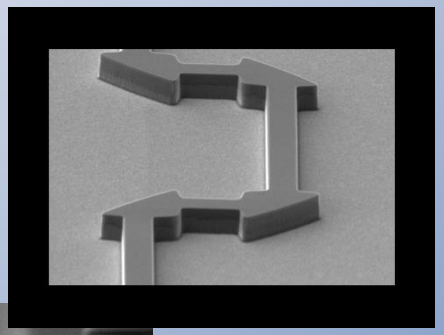
Process Sampling – Photonics Related

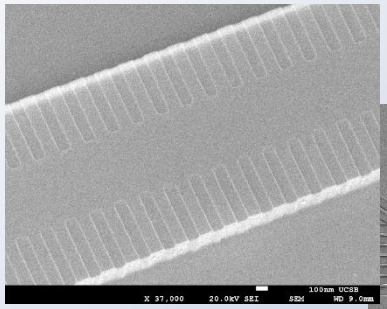
Lighting-GaN

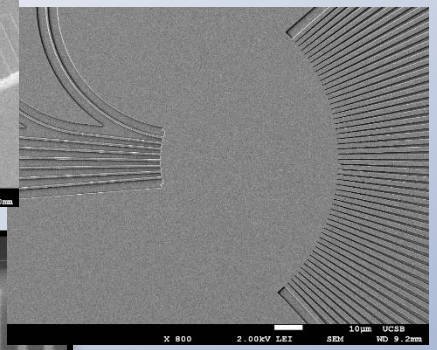


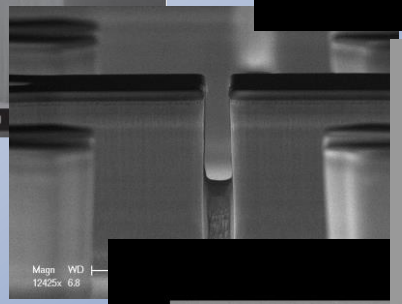


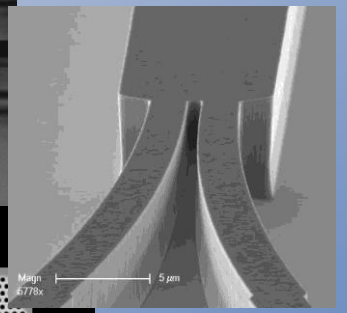




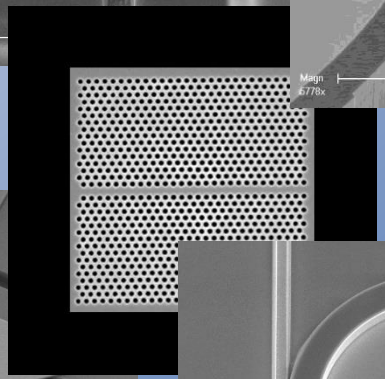


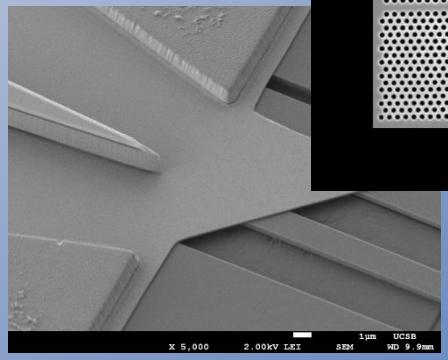


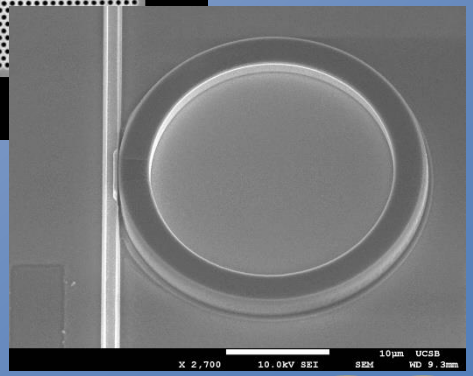


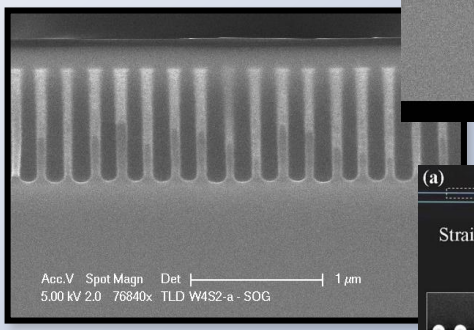


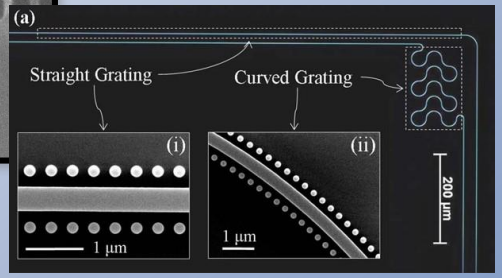
III-V InP









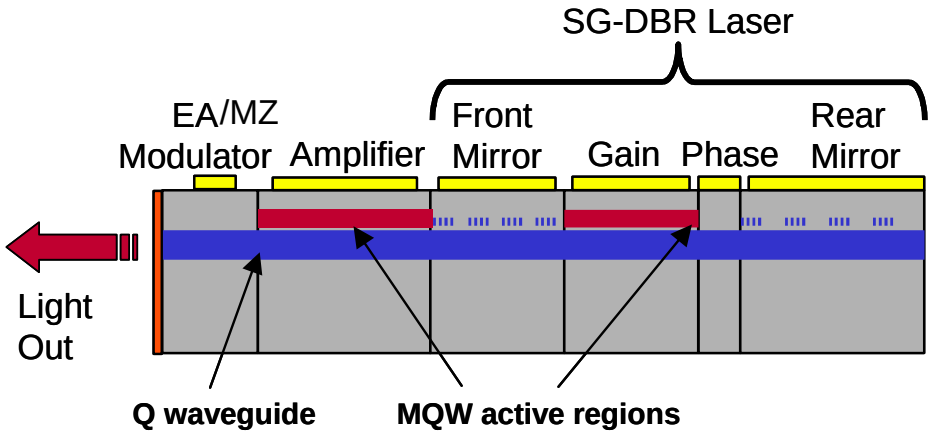


Si-Photonics

Example 1:

Agility Communications (Acq. JDSU 2005→ Lumentum)

- Formed 1998 by Coldren students + Coldren; based on fundamental 1988 UCSB patent filing
- Widely-tunable (full C-band) sampled-grating-DBR lasers with integrated SOAs and modulators; use of off-set quantum-wells for active-passive



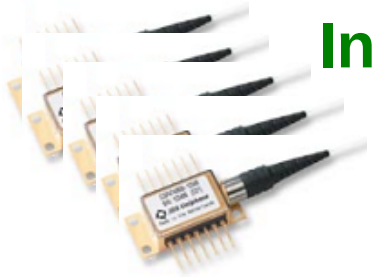
Advantages:

- smaller space
- lower cost
- lower power consumption
- high reliability

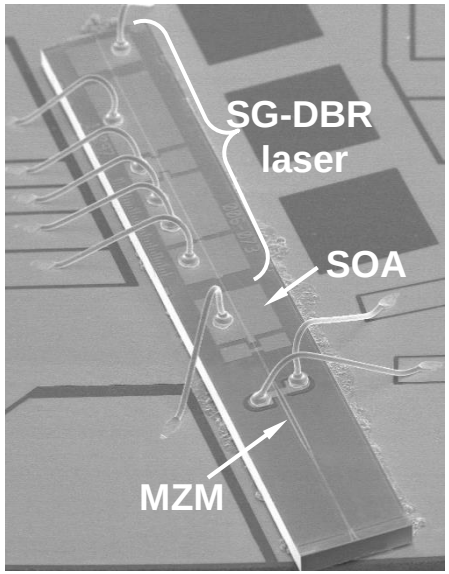
AGILITY

Agility's Unique Platform—2001-2005

Integration Replaces Discretes



Laser Source



Optical Amplifier

LN Modulator

VOA

Higher Reliability, Smaller Size, and Lower Cost:

- Significant Part Count Reduction for DWDM
- Eliminates Multiple Packaging
- Single Chip Reliability
- Only Tunable Integration Platform in the Market

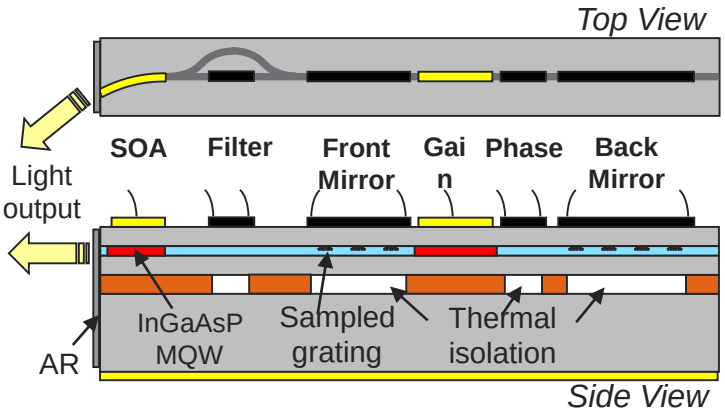
TunableTx/Rx Transponder with all control electronics primary product —2002→

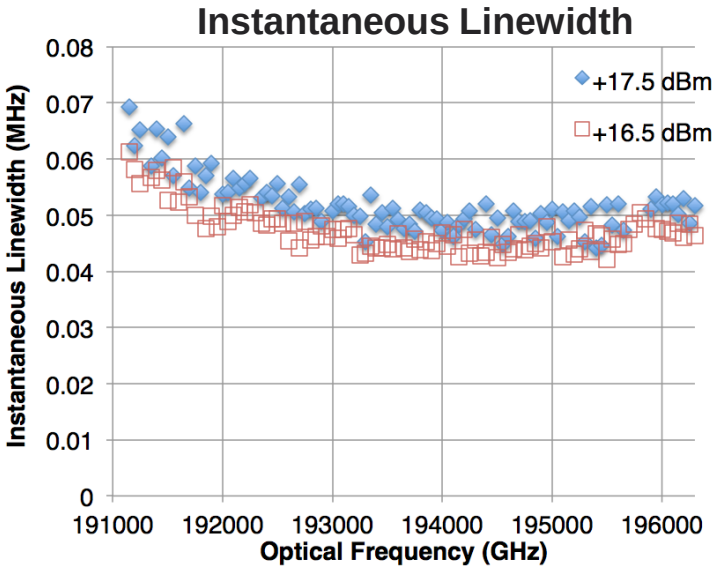
Integrated MZM after 2004

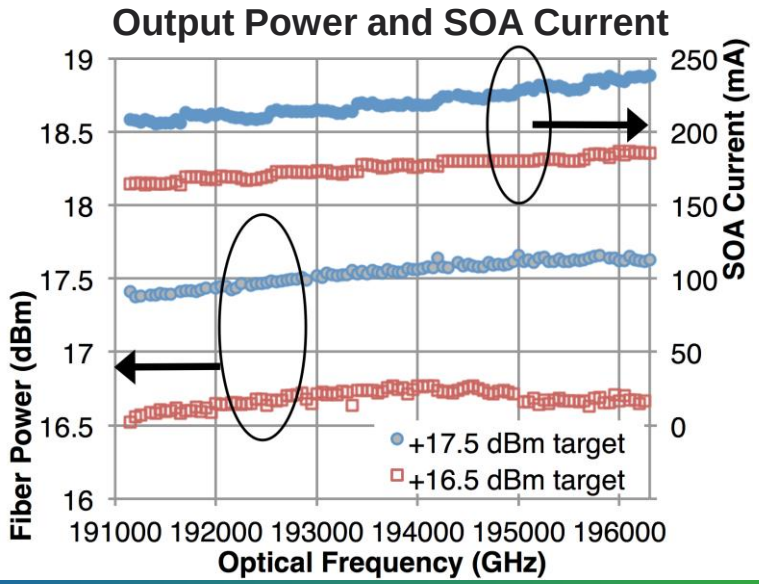
AGILITY

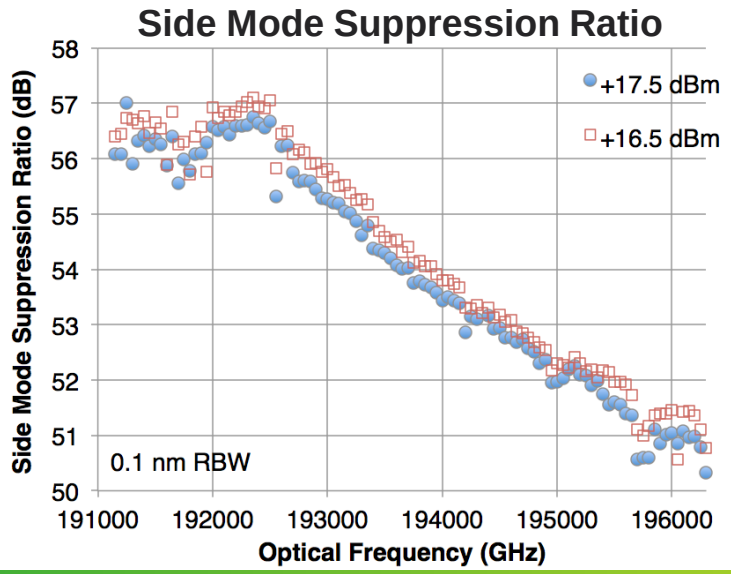
Narrow linewidth thermally-tuned SGDBR Laser—2015

- 70kHz linewidth and 50dB SMSR at +17dBm fiber power over 41nm range in C-band

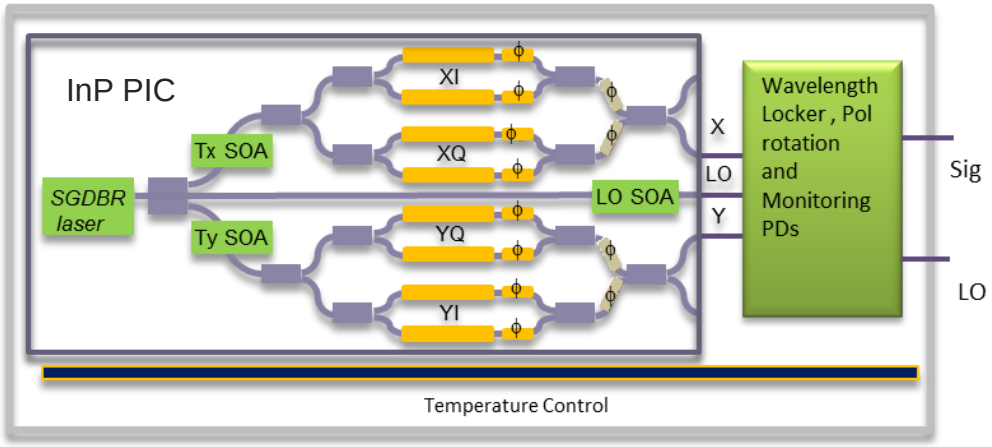


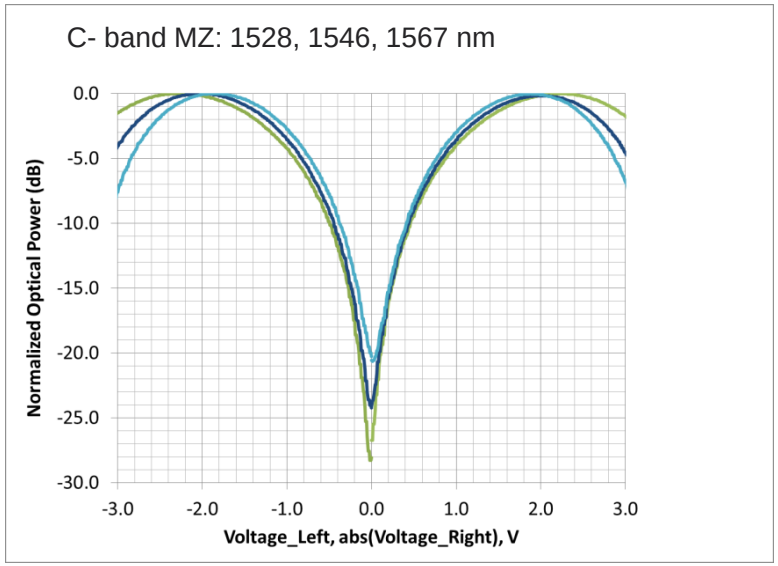




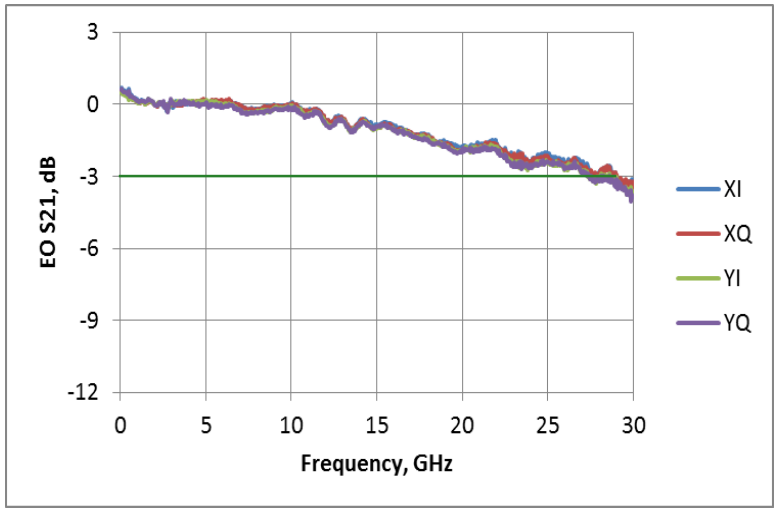


C-band Tunable Integrated Coherent Transmitter PIC





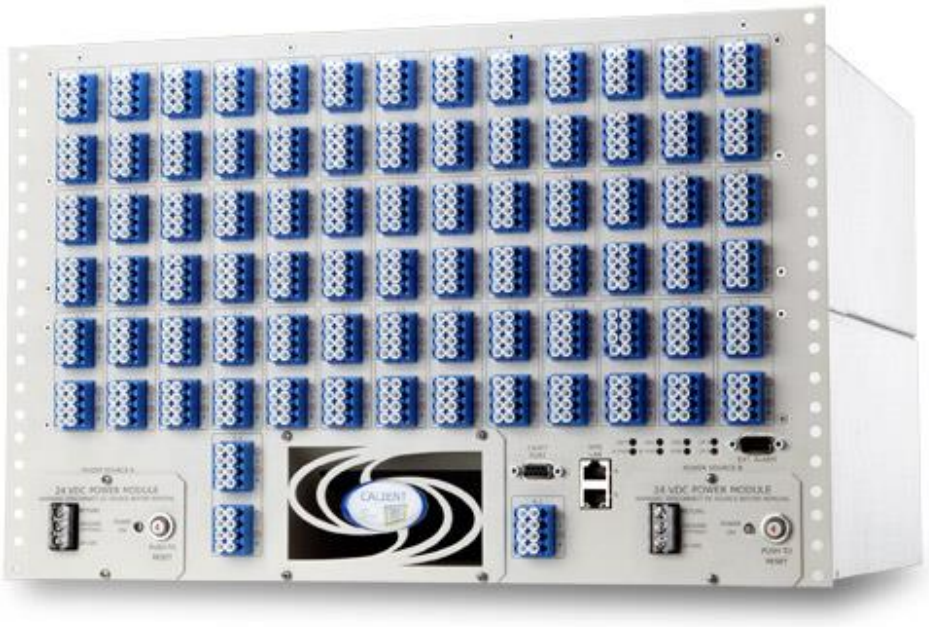
- Narrow Linewidth Sampled-Grating DBR laser
- Two quadrature Mach-Zehnder modulators
- High power LO output
- 3 SOAs
  - Independent power control for LO and each Tx polarization
  - VOAs
- InP PIC technology is employed for 32 Gbaud 100 and 200 Gb/s coherent pluggable modules

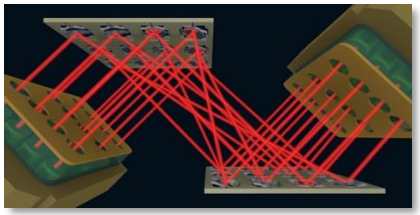


Example 2:

CALIENT's S-Series Optical Circuit Switch (OCS)

- **Up to 320 User Ports – 640 Single Mode Fiber Terminations**
  - 320x320, 160x160 options
- **10, 40, 100 Gbit/s per port and beyond**
- **25ms typical setup time (<50ms Max)**
- **Less than 30ns latency**
- **Ultra low power (<45w), small size (7RU)**
- **TL1, SNMP, OpenFlow, REST APIs**
- **Less than 3.0 dB Insertion Loss**



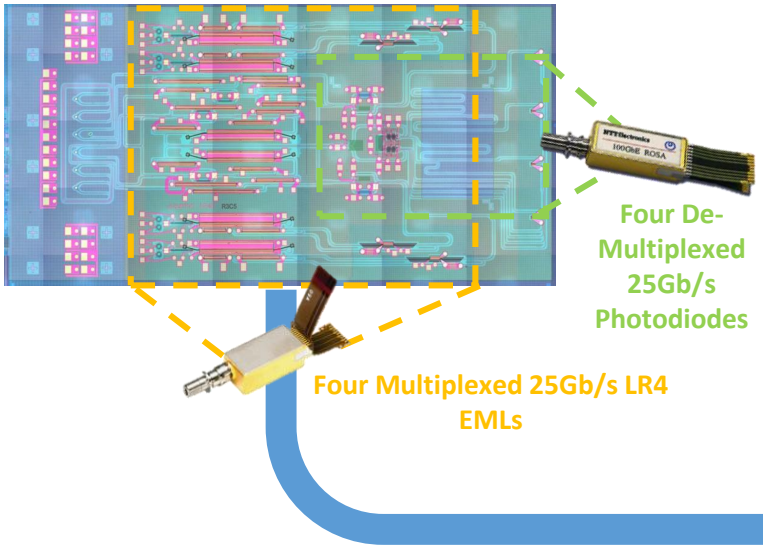


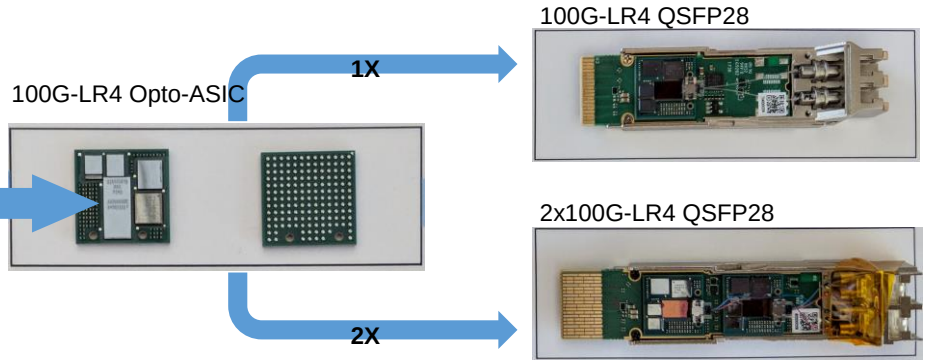
Founded by Bowers, et al, 2000
Acquired 2017, Suzhou Chunxing Prec. Mech.

Example 3:

Aurrion - Fully integrated Silicon Photonics

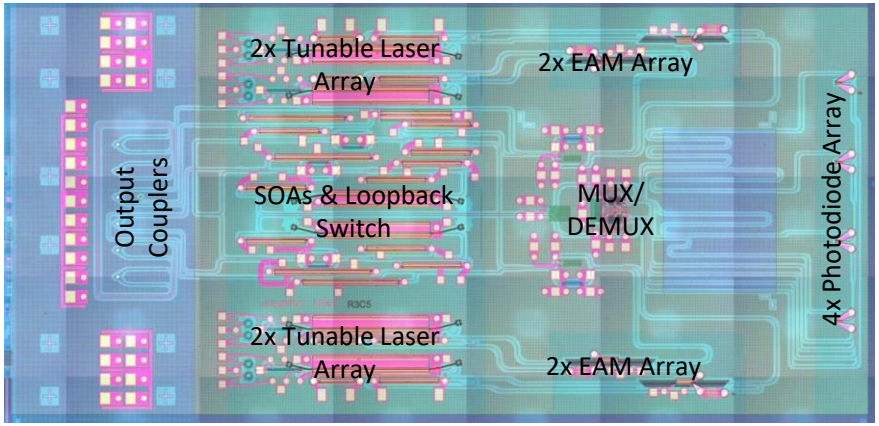
- Founded by Alexander Fang and John Bowers out of UCSB in 2008
- Acquired by Juniper Networks – 2016
- The Only Silicon Photonics Platform with WDM Lasers & SOAs (Heterogeneous integration of InGaAsP/SOI)
  - Uncooled WDM
  - Fully integrated with Modulators, and PDs
- Compatible with low cost silicon packaging
  - Supports Co-packaging with ASICS





Aurrion - Photonic Integrated Circuits (PICs)

- **Leveraging the economies of scale pioneered by the silicon industry**
  - Photonic Integrated Circuit (PIC) fabrication leverages silicon design, process, test, package, and foundry infrastructure for complete photonic systems
  - **Impact**: Fundamental and permanent improvements in cost per bit-per-second
- **Uncooled WDM technology**
  - No TEC required to operate over temperature
  - Integrated micro heaters keep wavelength sensitive components tuned to the wavelength grid
  - **Impact**: Higher capacities for networking interfaces
- **Packaged like an ASIC**
  - Packaged along side other ASICs on the same substrate
  - **Impact**: Greater flexibility in how bandwidth carried on light is processed inside the electronic portions of networking systems.
- **ASIC like Reliability**
  - Single-chip, solid state devices vs discrete components
  - **Impact:** Photonics that scale with the system



PIC stats
- 100Gb/s LR4 compliant
- Area = 34 mm^2
- 67 photonic components interconnected with waveguides
- Many components contain subcomponents (laser = 8)

Examples 4 & 5:

GaN Start-ups from UCSB

- Case Study 1: 1996—2000 Nitres (LED)
  - Prof. Mishra & DenBaars start Nitres Inc.-GaN LED and FET company in U.S.-Acquired by CREE Inc.
  - LED lightbulbs commercialized
- Case Study 2: 2013→ SLD Laser
  - Prof. Nakamura, Speck, DenBaars, et al spin-out GaN laser leader SLD Laser (from Soraa formed in 2008).
  - LaserLight commercialized
- Case Study 3-Transphorm
  - Prof. Mishra spins-out power switching company
  - GaN based Power supplies commercialized

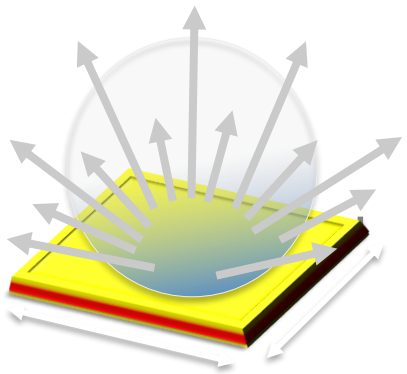
Cree, Inc. to Acquire Nitres, Inc., a Leader in Nitride Semiconductor Device Development; Company to Launch Solid State Lighting Subsidiary

Apr 11, 2000, 01:00 ET from Cree, Inc.

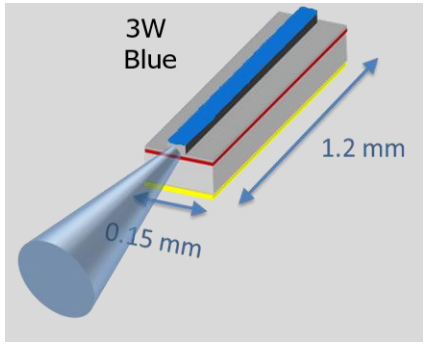
DURHAM, N.C., April 11 /PRNewswire/ -- Cree, Inc. (Nasdaq: Cree), the world leader in the development and manufacture of semiconductor materials and electronic devices made from silicon carbide (SiC), today announced it has signed a definitive agreement to acquire privately held Nitres, Inc., a leader in research and development of nitride-based semiconductor devices. Under the terms of the agreement, Cree will acquire all of the outstanding and vested shares of Nitres stock in exchange for approximately 1.5 million shares

Nitres founded in 1996 by DenBaars and Mishra

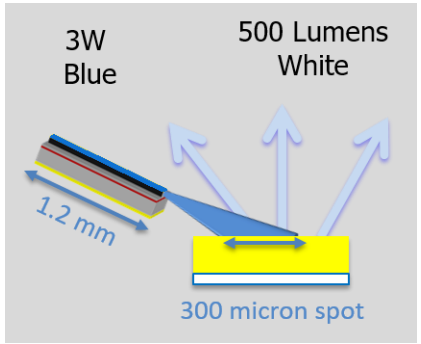
LASERLIGHT: THE NEXT GEN SSL SOURCE



- Low Luminance
- Droop/Auger
- Safe



- High Luminance
- >10k brighter vs LED
- >20X power per chip
- Not Safe



- High Luminance
- 100X brighter vs LED
- 500lm from 300um
- Safe

- **Incoherent emission provides safety & regulatory acceptance versus direct LD** **(Soraa continues in the first two boxes)**

SLDLASER

“Laser diodes are lighting’s future.”

Nobel Laureate Physics & SLD Laser Co-Founder
Shuji Nakamura

END

- Questions?