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??
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
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
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

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

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\[\to\] 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

New Venture Competition: TMP’s flagship entrepreneurial program

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

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

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

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

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

- **inogen**
- **APEEL SCIENCESTM**
- **TrackR**
- **Sirigen**
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

Find separate space/facility:
Outsource expensive fabrication/testing:

UCSB Shared Facilities

Nanotech 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

- ~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.

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, XeF₂, 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/Assembler**
- Dielectrics, Metals, Semiconductors
- Workhorse systems – often >18 Hrs/fday
- nm-scale control - reproducible
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
3D CDD
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
Aeonian Semiconductor Technology
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
Innovative III-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

Advanced Nanostructures
AdvR
Aeonian Semiconductor Technology
AlSthesis 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
Innovative III-V Solutions
Laser Components DG Inc
Laxense, Inc.
Laxmi Therapeutic Devices
Magic Leap
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

DNA Sequencing

THz transistors

InP-Photonic ICs

VCSELs

Microneedles

Solid-State Lighting, Photovoltaics, Thermoelectrics, Oxide Electronics
Process Sampling – Photonics Related

The convergence of research and innovation.

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’s Unique Platform—2001-2005

Integration Replaces Discretes

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
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
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
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

![Diagram showing Aurrion's silicon photonics platform](Image)
**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 mm²
- 67 photonic components interconnected with waveguides
- Many components contain subcomponents (laser = 8)
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
  - 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

- Incoherent emission provides safety & regulatory acceptance versus direct LD  
  (Soraa continues in the first two boxes)
“Laser diodes are lighting’s future.”
Nobel Laureate Physics & SLD Laser Co-Founder
Shuji Nakamura
• Questions?