

# Pathways Presentation:

## Physical electronics and photonics (formerly Solid-State Electronics)

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# Total of 33 faculty members ( 7 of them work in multiple areas)

## U.S. News & World Report

**#37** Undergraduate Program [22nd among public institutions]

**#42** Graduate Program [23rd among public institutions]

**#27** Electrical Engineering Graduate Program

[David Allee\\*](#)

[Hugh Barnaby\\*](#)

[Mariana Bertoni](#)

[Jennifer Blain Christen\\*](#)

[Yu Cao\\*](#)

[Junseok Chae\\*](#)

[David Ferry](#)

[Gennady Gildenblat](#)

[Stephen Goodnick](#)

[Michael Goryll](#)

[Zachary Holman](#)

[Christiana Honsberg](#)

[Michael Kozicki](#)

[Richard Kiehl](#)

[Richard R. King](#)

[Ying-Cheng Lai](#)

[Cun-Zheng Ning](#)

[George Pan\\*](#)

[Stephen Phillips](#)

[Marco Saraniti](#)

[Brian Skromme](#)

[Meng Tao](#)

[Nongjian Tao](#)

[Trevor Thornton](#)

[Dragica Vasileska](#)

[Chao Wang](#)

[Yu Yao](#)

[Hongbin Yu](#)

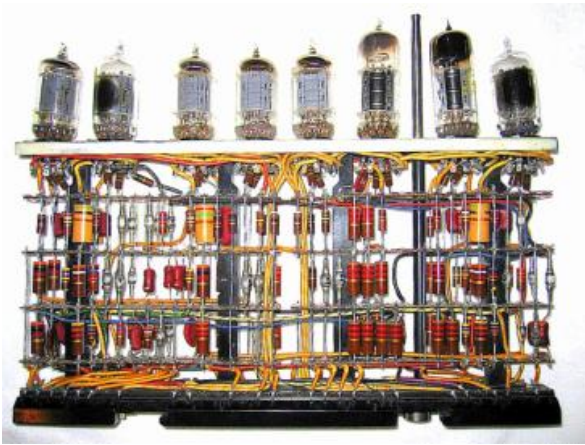
[Hongyu Yu](#)

[Shimeng Yu\\*](#)

[Yong-Hang Zhang](#)

[Yuji Zhao](#)

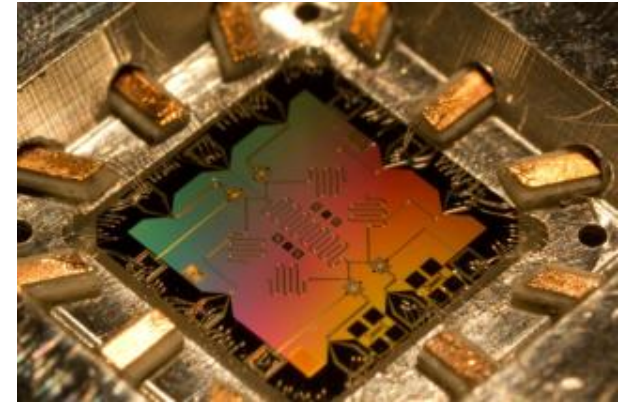
# Physical Electronics: The science and technology of materials, devices and systems that involve the control of electrons



Vacuum tubes (pre-solid-state)



First transistor



VLSI Integrated circuit



UNIVAC mainframe



Mac 128k

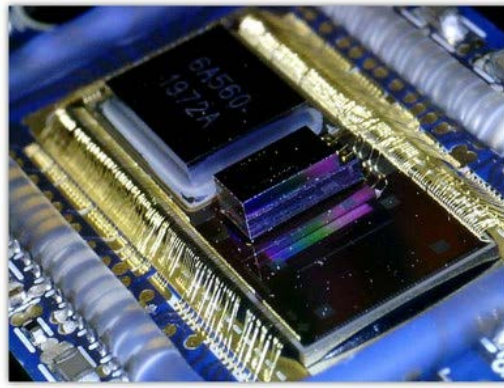


Apple MacBook Air

# Photonics: The science and technology of generating, controlling, and detecting light waves and photons, which are particles of light



LEDs and Lasers



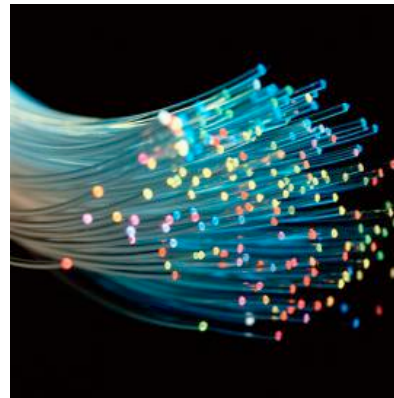
Integrated Photonics



Solar cells



Modules



Fiber Communications



Optical network





# Semiconductor Industry Market

## Worldwide Semiconductor Market Product Breakdown (2015)

<b>Total Semiconductors - \$335.2B</b>					
<b>Integrated Circuits - \$274.5B</b>					<b>Discretes Sensors &amp; Opto \$60.7B</b>
<b>Digital - \$229.3B</b>				<b>Analog \$45.2B</b>	
<b>MOS - \$229.3B</b>				Discretes \$18.6B	Opto \$33.3B
		General Purpose \$18.6B	App. Specific \$26.6B		
<b>Memory - \$77.2B</b>		<b>Micro - \$61.3B</b>		<b>Logic - \$90.8B</b>	
DRAM \$45.0B	Flash \$30.4B	MPU \$43.3B	MCU \$15.5B	Special Purpose Logic \$70.2B	Standard Logic \$20.6B

SRAM \$0.4B  
 Non-volatile memory; ROMs; EPROM; EEPROM \$1.4B  
 DSP \$2.5B

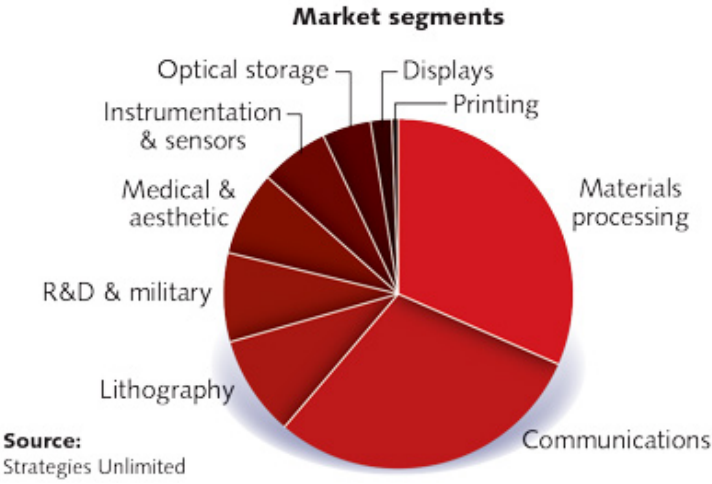
Sensors \$8.8B

Note: Numbers are rounded  
 Source: WSTS

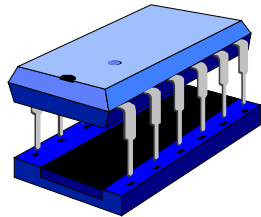


# Photonics Market

- ◆ The global photonics market size, which was \$452 Billion in 2015, is estimated to reach \$724 Billion by 2021, at a CAGR of 8.4% between 2016 and 2021
  - Worldwide laser sales forecast: 4.2% growth in 2016 to nearly \$10.5 billion
    - » Material processing (\$4.26B)
    - » Communication and optical storage (\$3.5B)
    - » Scientific research and military (\$886M)
    - » Medical and aesthetic (\$859M)
    - » Instrumentation and sensors (\$675M)
    - » Entertainment, displays & printing (\$307M)



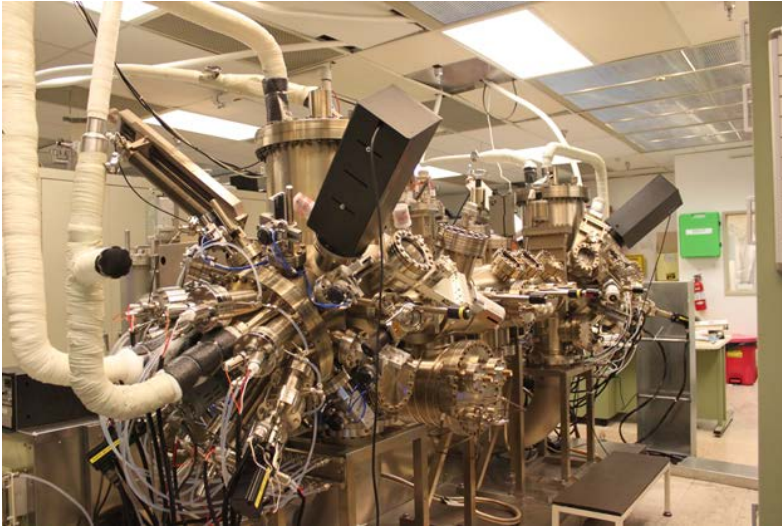
# Semiconductor Electronics and Photonics



- ◆ Electronic systems are driven by semiconductor chips
- ◆ These chips perform *analog* and *digital* circuit functions
- ◆ Semiconductor chips contain *semiconductor devices*
- ◆ Semiconductor devices have to be
  - Designed, fabricated, measured, modeled, marketed, and sold
- ◆ Need to know:
  - Device physics
  - Circuit design
  - Fabrication techniques
  - Modeling
  - Measurements

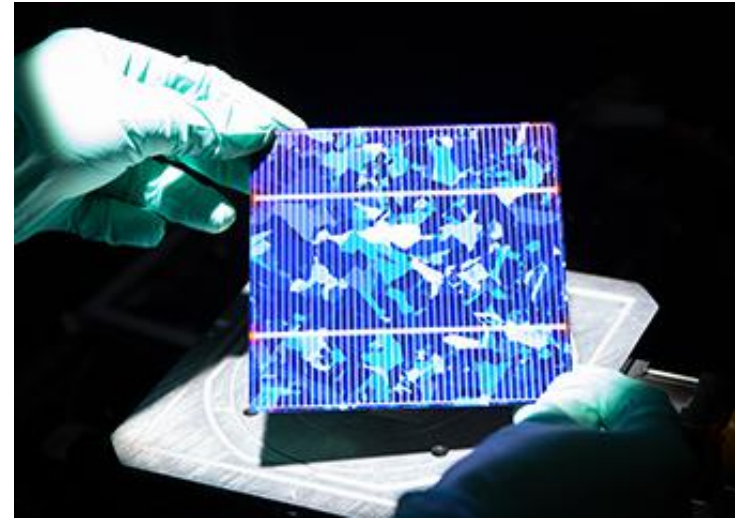


# Faculty and their research in our area



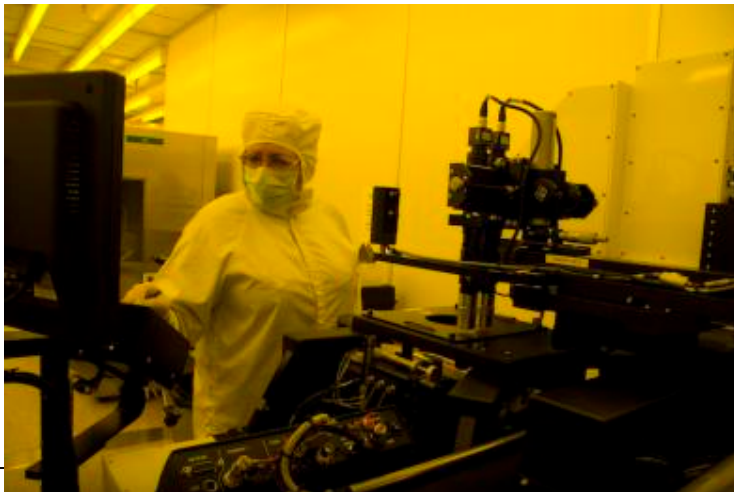
## Electronic and Photonic Materials

(Zhang, Zhao, Bertoni, Honsberg, Yu, Ning, ...)



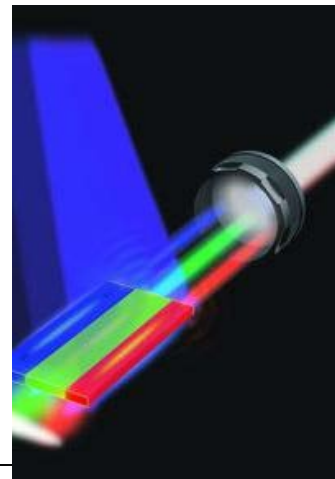
## World-class solar research

(Bertoni, Bowden, Goodnick, Holman, Honsberg, King, Tao, Vasileska, Zhang, Zhao, ...)



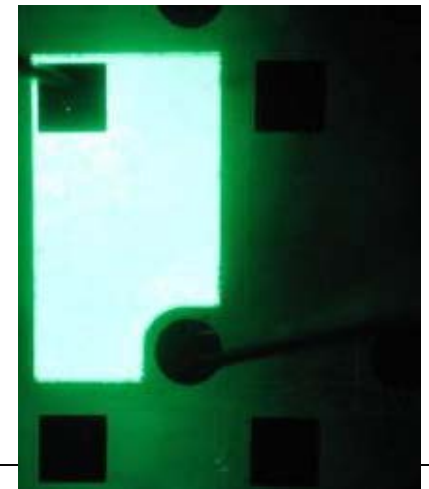
## Nanofabrication facility

(Thornton, Kozicki, Chae, Wang...)



## Lasers and nitride LED

(Ning, Zhao, Yu, ...)



# Semiconductor Industry

*What do engineers in the semiconductor industry do?*

- ◆ **Circuit design**
  - Design and lay out circuits to be manufactured
- ◆ **Simulation/modeling**
  - Simulate semiconductor device, circuit, and systems behavior (simulation is faster and cheaper than manufacturing)
- ◆ **Fabrication**
  - Fabricate these circuits, maintain yield
- ◆ **Measurement/characterization**
  - Characterize the performance of the devices/circuits/chips
- ◆ **Sales/marketing**
  - Sell and market devices, chips, systems, equipment, services

# Job Opportunities

- ◆ **Electronic Device, IC and System Manufacturers**
  - Freescale, On Semiconductor, Intel, Microchip, Micron
  - Texas Instruments, National Semiconductor,
  - ST Semiconductors, Global Foundries, Infineon
  - IBM, HP, Dell, Apple
- ◆ **Photonics industry**
  - Lumileds, CREE,
  - First Solar, SunPower, Boeing-Spectrolab, SolAero, Solar Junction
  - Emcore, Finisar, Luxtera, Intel, Infinera, NeoPhotonics, Oclaro
  - nLight, Trumpf Laser, Coherent, IPG Photonics
  - Raytheon, Boeing, Lockheed-Martin, Northrop Grumman, HRL
- ◆ **Equipment Manufacturers**
  - Applied Materials, KLA/Tencor, Lam, ASM
  - Chemical Cos., Digital Instruments
  - Agilent, Keithley, Newport
- ◆ **Services**
  - Companies producing simulation software, other services

# Graduate school?

## ◆ *BS*

- Entry-level degree
- For technical work you'll be at the lower end of the range of engineers
- For less technical work, good

## ◆ *MS*

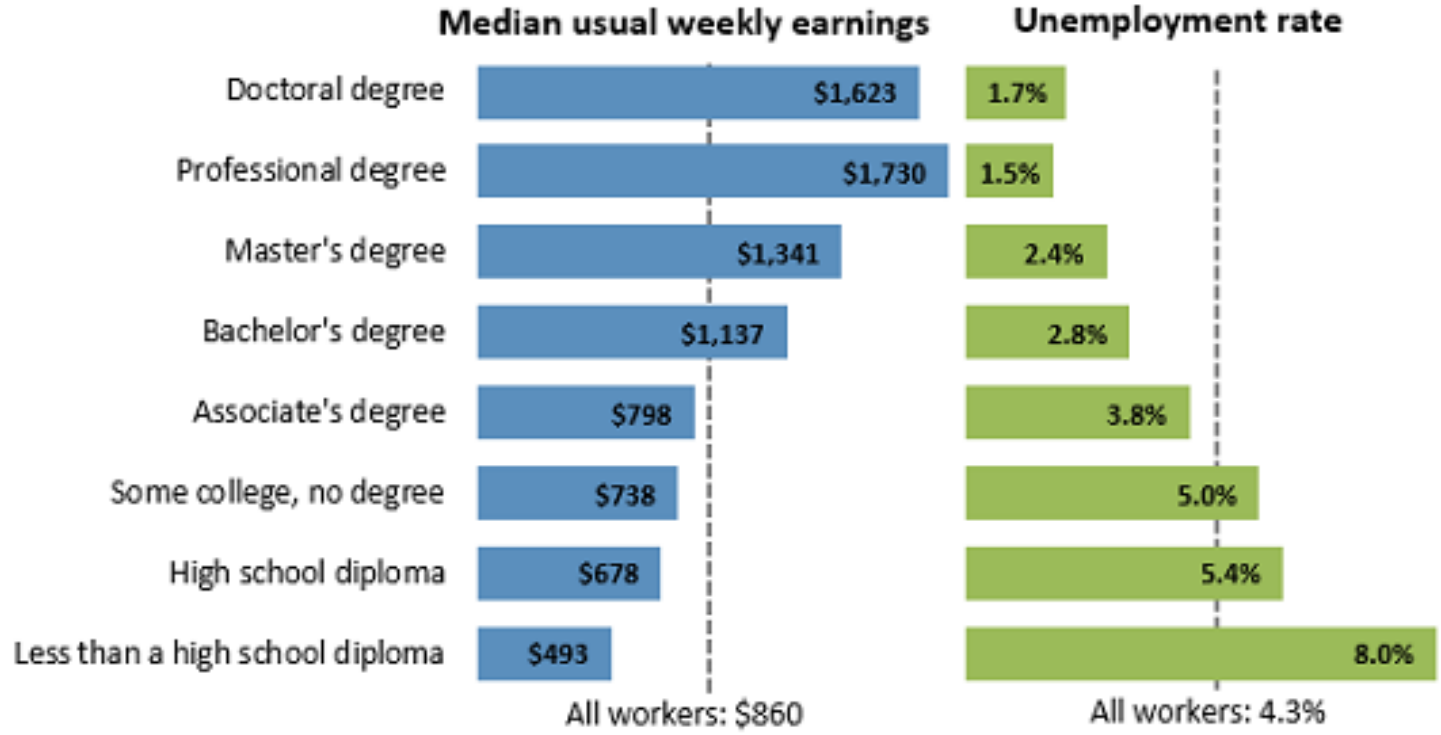
- Good degree
- Valued by industry
- More advanced knowledge, but not overly specialized
- Most useful degree for most cases

## ◆ *PhD*

- Specialized
- Good for those interested in more advanced, more interesting work
- Necessary for academic or R&D careers

# Graduate school?

## Earnings and unemployment rates by educational attainment, 2015



Note: Data are for persons age 25 and over. Earnings are for full-time wage and salary workers.  
Source: U.S. Bureau of Labor Statistics, Current Population Survey

**Knowledge is power --- Francis Bacon**





# Courses

- ◆ **EEE 434 – Quantum Mechanics for Engineers**
  - Basic physics describing the behavior of electrons and atoms *Quantum world is fascinating!*
- ◆ **EEE 435 – Fundamentals of CMOS and MEMS**
  - Fabrication of semiconductor devices/circuits. *The building block of electronics!*
- ◆ **EEE 436 – Fundamentals of Solid State Devices**
  - Introduces the physics of the most common semiconductor devices, *i.e.*, how do these device work. *Important physics!*
- ◆ **EEE 437 – Optoelectronics**
  - Light emitting/detecting devices (lasers, LEDs photodetectors, solar cells etc.) *Emerging technologies!*
- ◆ **EEE 439 – Semicond. Facilities/Cleanroom Practices**
  - Facilities/cleanrooms to make semiconductors *Manufacturing is the king!*
- ◆ **EEE 465 – Photovoltaic Energy Conversion**
  - The science, manufacturing and economics of producing electricity from solar energy *Sustainability is the future!*