EE 232 Lightwave Devices
Lecture 1: Overview and Introduction

Instructor: Ming C. Wu

University of California, Berkeley
Electrical Engineering and Computer Sciences Dept.

Course Information (1)

- **Website:** www-inst.eecs.berkeley.edu/~ee232/sp15/
  - All lecture notes, homeworks will be posted there
  - HW and exam scores will be posted in bCourses
  - Discussion in Piazza: https://piazza.com/class/i5bmwx802065n
- **Instructor:**
  - Prof. Ming Wu (511 SDH, wu@eecs)
  - GSI: Ryan Going (rwgoing@eecs)
- **Lectures: Tu/TH, 3:30 to 5:00 pm @ 299 Cory**
- **Discussion: Monday 4-5 pm @ 299 Cory**
- **OH: Tue 2-3 @ 511 SDH**
- **Textbook (on reserve in Eng Lib)**
  - S.L. Chuang, *Physics of Photonic Devices*, 2nd Edition, John Wiley and Sons, 2009

Course Information (2)

- **Reference Books** (on reserve at Engineering Library)
  - Yariv & Yeh, *Photonics: Optical Electronics in Modern Communications*, Oxford University Press, 2006
  - L A Coldren; S W Corzine; Milan Mashanovitch, *Diode Lasers and Photonic Integrated Circuits*, John Wiley & Sons, 2012
  - Saleh & Teich, Fundamentals of Photonics, 2nd Ed. Wiley, 2007
- **PREREQUISSITES**
  - **EECS 130:** Simple p-n junction, semiconductor physics, concept of energy bands, Fermi levels.
  - **PHYS 137A:** recommended. Basic concept of quantum mechanics, perturbation theory
  - **EECS 117:** recommended. Concept of dielectric waveguide, electromagnetic waves.

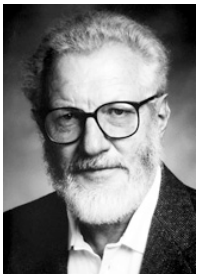
Course Information (3)

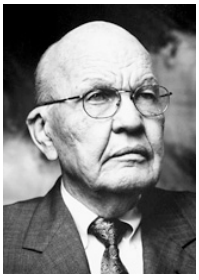
- **EXAM & GRADES**
  - **Homework** **30%**
  - **2 Midterms** **20% + 20%**
  - **Final Exam** **30%**
- **Final Exam**
  - **Final Exam Group:** **20**
  - **FRIDAY, MAY 15, 2015 7-10P**
    (may move to the week before RRR, pending on everybody's availability)
- **HW policy**
  - **Discussion is permitted (and encouraged), but you must do your own HW, including literature search, derivation, or calculation.**

Course Information (4)

- **Simulation project (part of HW)**
  - **Sentaurus device simulation**
    - **Edge emitting lasers**
    - **(New feature this semester, still evolving)**
  - **Passive optical components (initial inquiry with vendor)**
  - **Photonic integrated circuits**

The Nobel Prize in Physics 2000





Zhores I. Alferov, **Herbert Kroemer,** **Jack S. Kilby**

The Nobel Prize in Physics 2000 was awarded *"for basic work on information and communication technology"* with one half jointly to Zhores I. Alferov and Herbert Kroemer *"for developing semiconductor heterostructures used in high-speed- and opto-electronics"* and the other half to Jack S. Kilby *"for his part in the invention of the integrated circuit".*

The Nobel Prize in Physics 20

Isamu Akasaki

Hiroshi Amano

Shuji Nakamura

The Nobel Prize in Physics 2014 was awarded jointly to Isamu Akasaki, Hiroshi Amano and Shuji Nakamura *"for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources"*.

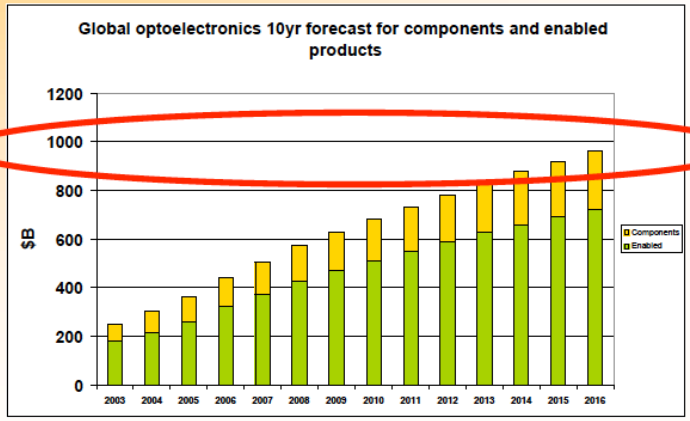
Common Optoelectronic Components

Optoelectronics Market Segment

- Flat panel displays
  - PC, Tablet, TV, mobile devices, head-mount displays
- High brightness LEDs
  - Solid state lighting, large display panels, automotive applications, LCD backlighting
- Imaging array sensors
  - Digital cameras
- Diode lasers
  - Data communications and telecommunications
  - Computer mice
  - High power laser pumping source
- Renewable energy
  - Solar cells

Next decade in optoelectronics

- Combined OE components and enabled products
  - 2004-16 CAGR 11%

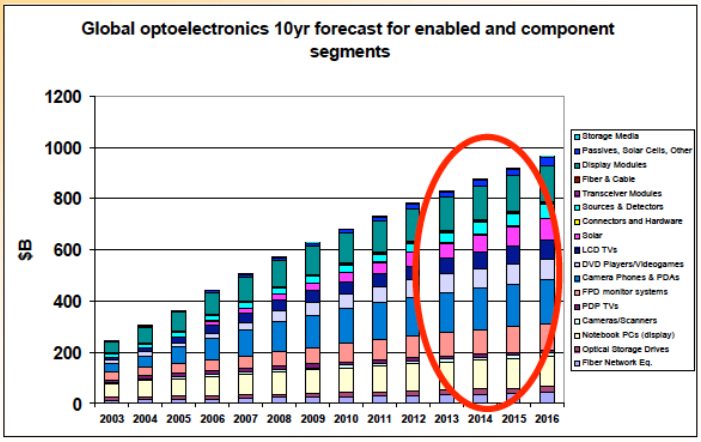


Michael Lebby (lebby@oida.org)

Is this a $T industry?

Next decade optoelectronics segments

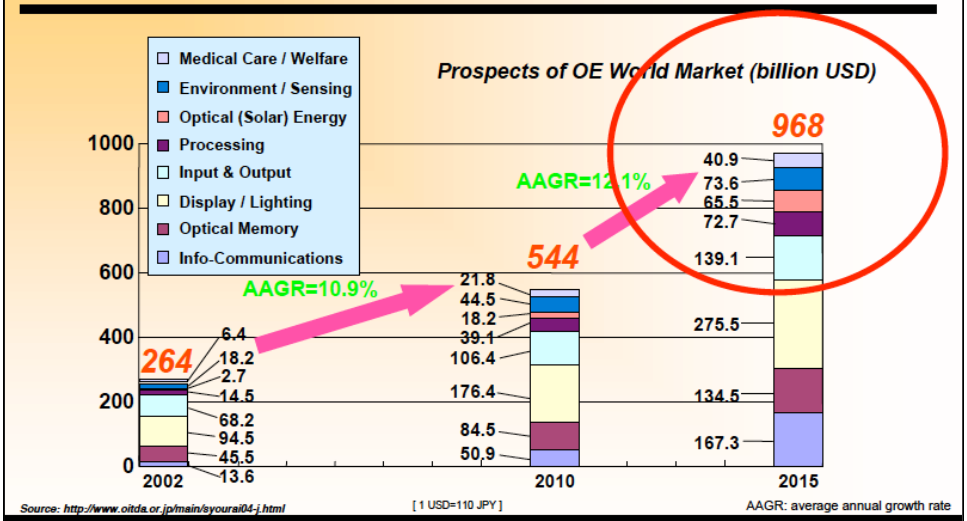
- Strong consumer/entertainment drivers



Michael Lebby (lebby@oida.org)

Displays grow more slowly

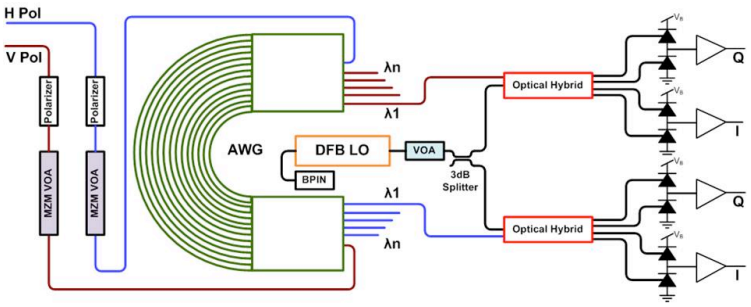
Japanese future vision



Michael Lebby (lebby@oida.org)

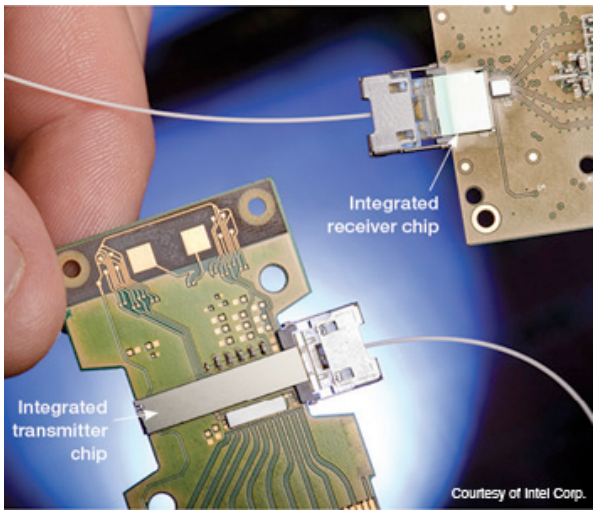
OITDA expects $1T OE business

Photonic Integrated Circuits (PIC) for Telecommunication Networks

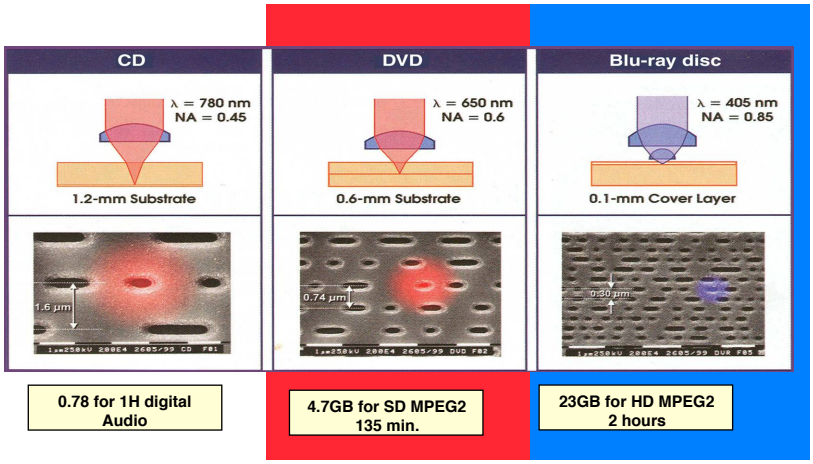


Infinera

Silicon Photonic Links

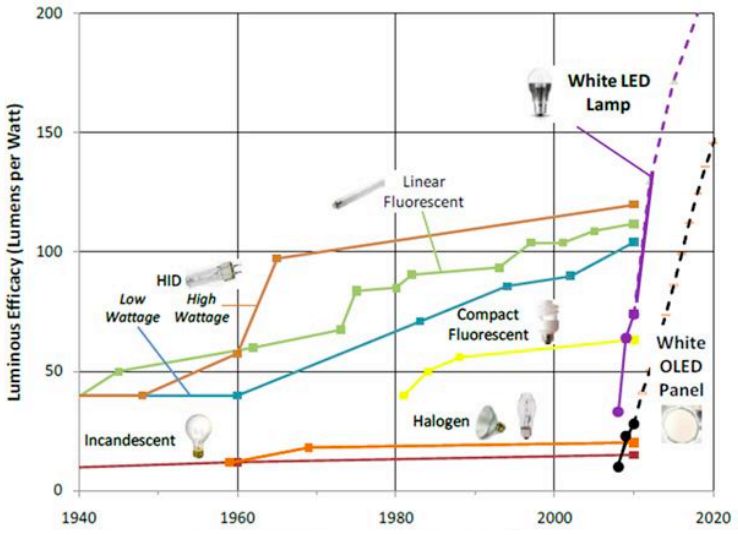


InGaN (405nm) for Optical Storage



Source: Photonics Spectra, Jan. 2004. LaserFocusWorld Marketplace Seminar

Evolution of LED Materials/Performances



Packaged LEDs

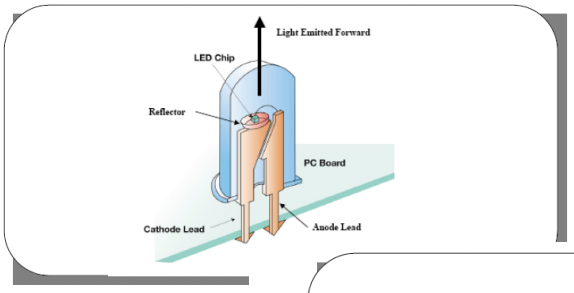


Figure 3.24: HB LED Cross Section

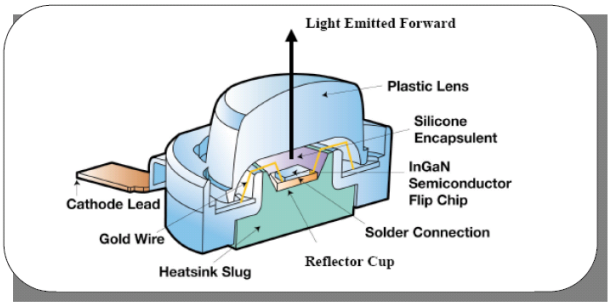
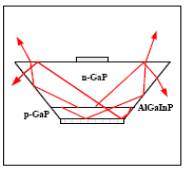
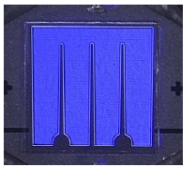


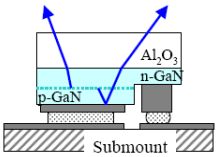
Figure 3.25: A High-Power HB LED Cross Section–Note the Heat Sink Size

HB-LED Technology

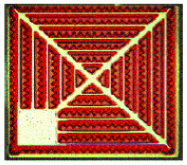


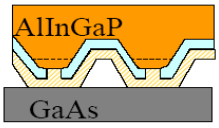
AlInGaN flip-chip (Lumiled)



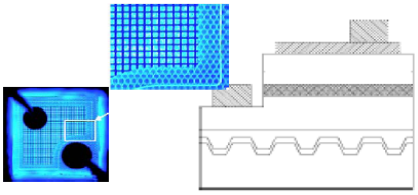


AlGaInP/GaP truncated inverted pyramid (Lumiled)





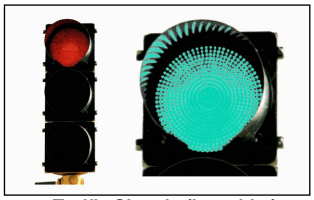
AlInGaP micro mirror (Osram),



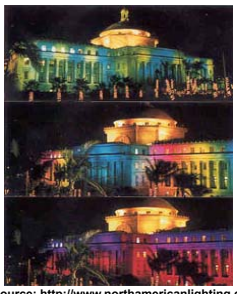
AlInGaN patterned substrate and mesh electrode (Nichia)

Source: LumiLeds

Applications of HBLEDs



Traffic Signals (inc white)



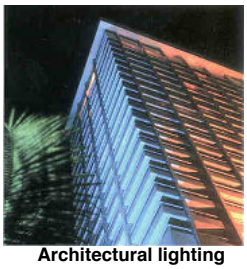
Source: http://www.northamericanlighting.com

Source: Toshiba (Technorainbow)

Outdoor lighting scenarios

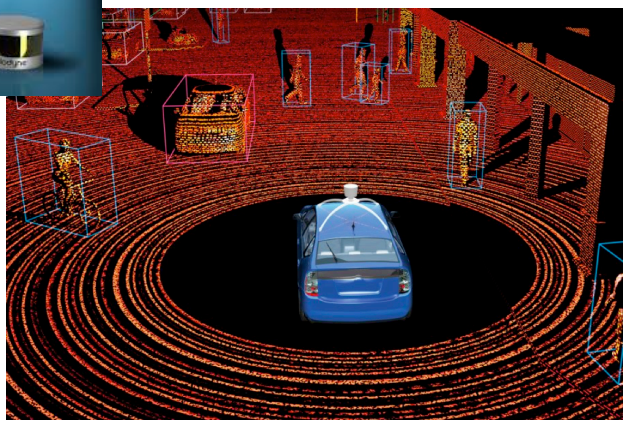
Source: Wustlich Design AG

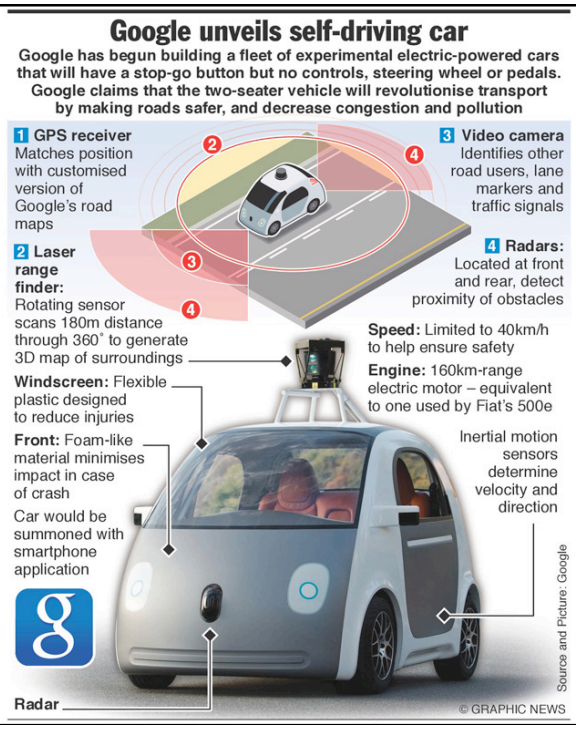
Furniture Lighting



Architectural lighting

3D Imaging: Velodyne LIDAR





Flat Panel Display - LCD

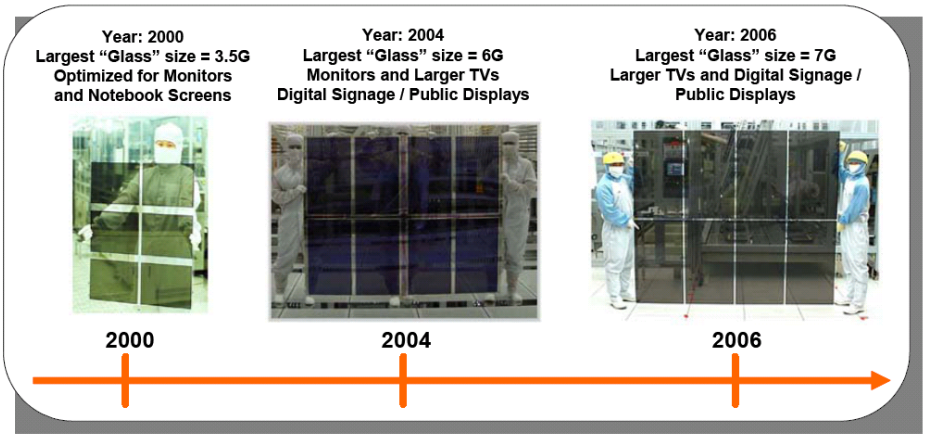


Figure 4.46: Glass Panel Trends

10G: glass size = 2.88m x 3.13m