EE 232 Lightwave Devices
Lecture 1: Overview and Introduction

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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)
Course Information (2)

• **Reference Books** (on reserve at Engineering Library)
  – Yariv & Yeh, *Photonics: Optical Electronics in Modern Communications*, Oxford University Press, 2006

• **PREREQUISITES**
  – EECS 130: Simple p-n junction, semiconductor physics, concept of energy bands, Fermi levels.
  – PHYS 137A: recommended. Basic concept of quantum mechanics, perturbation theory

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

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”.

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

Global optoelectronics 10yr forecast for components and enabled products

Is this a $T industry?
Next decade optoelectronics segments

- Strong consumer/entertainment drivers

Global optoelectronics 10yr forecast for enabled and component segments

Displays grow more slowly

Japanese future vision

Prospects of OE World Market (billion USD)

OITDA expects $1T OE business
Photonic Integrated Circuits (PIC) for Telecommunication Networks

Silicon Photonic Links

Infinera

Integrated receiver chip

Integrated transmitter chip

Courtesy of Intel Corp.
InGaN (405nm) for Optical Storage

<table>
<thead>
<tr>
<th>Medium</th>
<th>Wavelength</th>
<th>Numerical Aperture (NA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>λ = 780 nm</td>
<td>NA = 0.45</td>
</tr>
<tr>
<td>DVD</td>
<td>λ = 650 nm</td>
<td>NA = 0.6</td>
</tr>
<tr>
<td>Blu-ray</td>
<td>λ = 405 nm</td>
<td>NA = 0.85</td>
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- 1.2-mm Substrate
- 0.8-mm Substrate
- 0.1-mm Cover Layer

0.78 for 1H digital Audio
4.7GB for SD MPEG2 135 min.
23GB for HD MPEG2 2 hours


Evolution of LED Materials/Performances
Packaged LEDs

Figure 3.24: HB LED Cross Section

HB-LED Technology

AlInGaN flip-chip (Lumiled)

AlGaN/GaP truncated inverted pyramid (Lumiled)

AlInGaN micro mirror (Osram),

AlInGaN patterned substrate and mesh electrode (Nichia)

Source: Lumileds

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

Traffic Signals (inc white)

Outdoor lighting scenarios

Source: Toshiba (Technorainbow)

Furniture Lighting

Source: http://www.northamericanlighting.com

Architectural lighting

3D Imaging:
Velodyne LIDAR

EE232 Lecture 1-19  Prof. Ming Wu

EE232 Lecture 1-20  Prof. Ming Wu
Google unveils self-driving car

Google has begun building a fleet of experimental electric-powered cars that will have a stop-go button but no controls, steering wheel or pedals. Google claims that the two-seater vehicle will revolutionise transport by making roads safer and decreasing congestion and pollution.

- **GPS receiver**: Matches position with customised version of Google’s road maps.
- **Laser range finder**: Rotating sensor scans 180° distance through 360° to generate 3D map of surroundings.
- **Windscreen**: Flexible plastic designed to reduce injuries.
- **Front**: Foam-like material minimises impact in case of crash.
- **Car would be summoned with smartphone application**.
- **Video camera**: Identifies other road users, lane markers and traffic signals.
- **Radars**: Located at front and rear, detect proximity of obstacles.

**Speed**: Limited to 40km/h to help ensure safety.

**Engine**: 150km-range electric motor – equivalent to one used by Fiat’s 500e.

**Inertial motion sensors** determine velocity and direction.

Flat Panel Display - LCD

**Figure 4.46: Glass Panel Trends**

10G: glass size = 2.88m x 3.13m