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/sp18/
  - All lecture notes, homeworks will be posted there
  - HW and exam scores will be posted in bCourses
  - Discussion in Piazza
- **Instructor:**
  - Prof. Ming Wu (511 SDH, wu@eecs)
  - GSI: Kevin Han (kyh@eecs)
- **Lectures:** TuTh 12:40-2:00P | 293 Cory
- **Discussion:** Wed 2:10-3:00P | 293 Cory
- **OH: tbd**
- **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
  - [Reference for discussion session] Lukas Chrostowski and Michael Hochberg. *Silicon Photonics Design: From Devices to Systems*. Cambridge University Press, 2015.
- **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
  - **EECS 117:** recommended. Concept of dielectric waveguide, electromagnetic waves.

Course Information (3)

- **EXAM & GRADES**

– Homework	20%
– 2 Midterms	20% + 20%
– Final Exam	20%
– Projects	20%

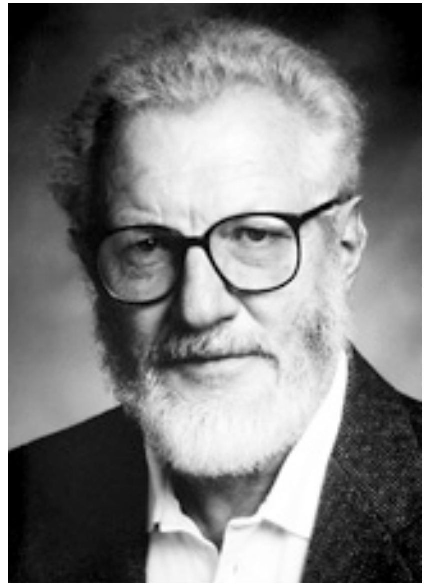
- **Final Exam**
  - At Last lecture
- **HW/Project policy**
  - Discussion is permitted (and encouraged), but you must do your own HW, including literature search, derivation, or calculation.
  - The subject of your project should not be exactly the same as other students

Course Information (4)

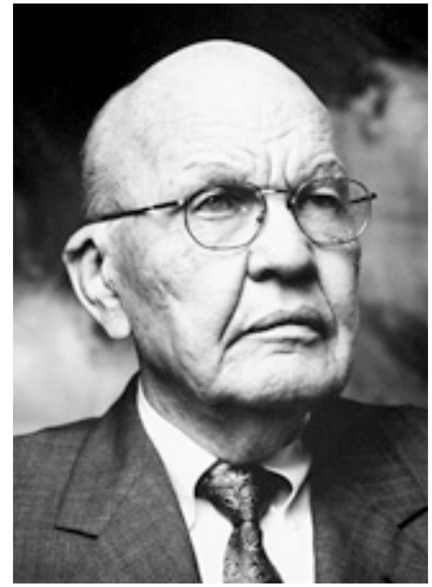
- Discussion Session
  - GSI, Kevin Han, will go over introduction to Lumerical simulation tool, and discuss various design examples
  - Attendance is mandatory since the materials do not overlap with lecture materials
  - Bring your laptop (Lumerical will be installed on your laptop)
- Project
  - Project will include design and simulation of new optoelectronic devices or circuits. The passive optical components need to be simulated using Lumerical.
  - Some examples will be given in discussion session.

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 2014

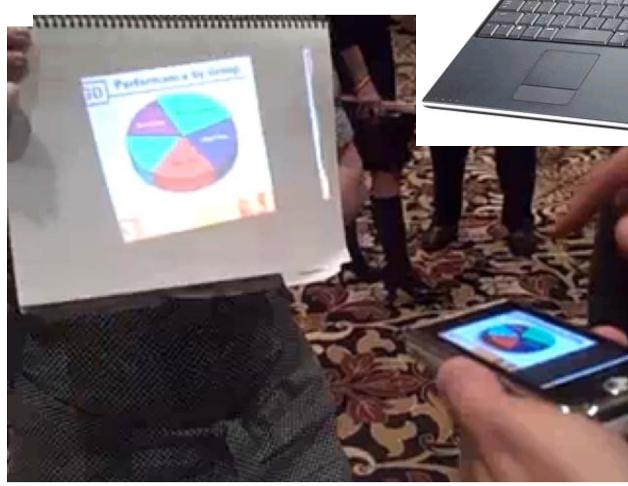
Isamu Akasaki

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"*****.**

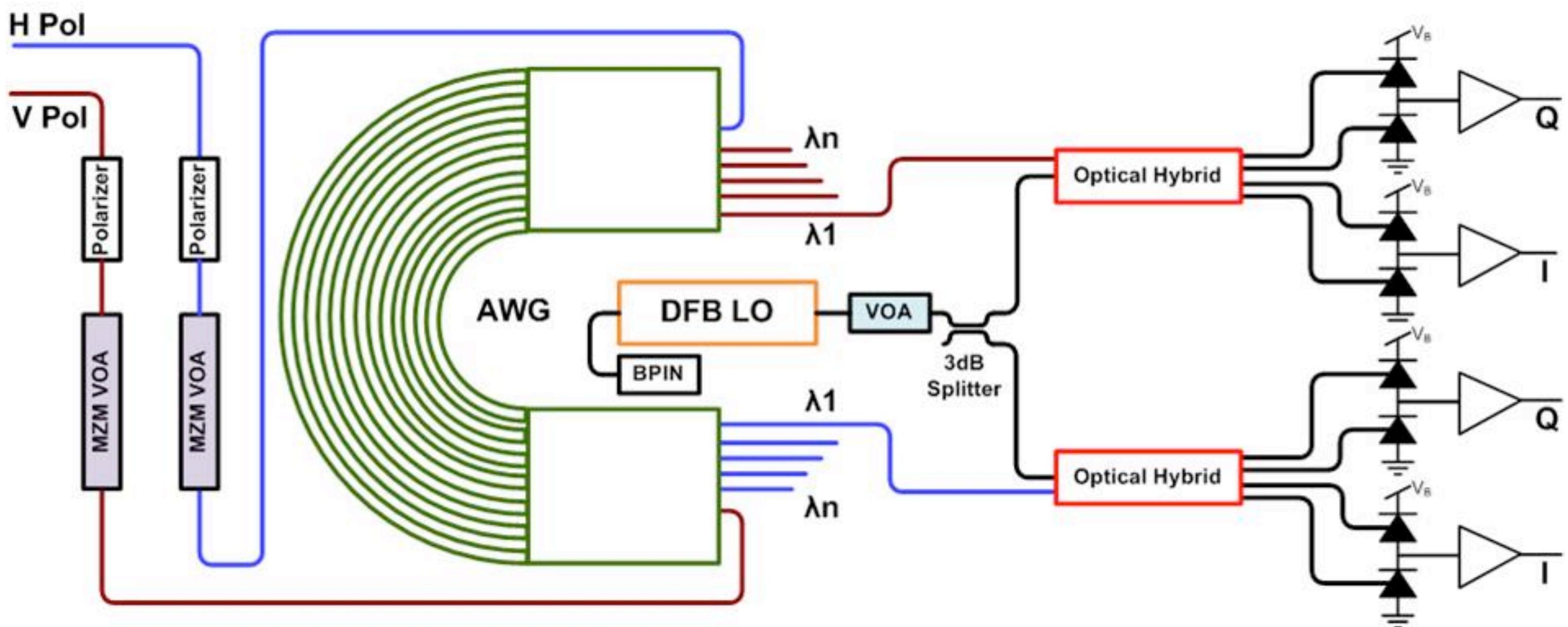
Common Optoelectronic Components



Optoelectronics Market Segment

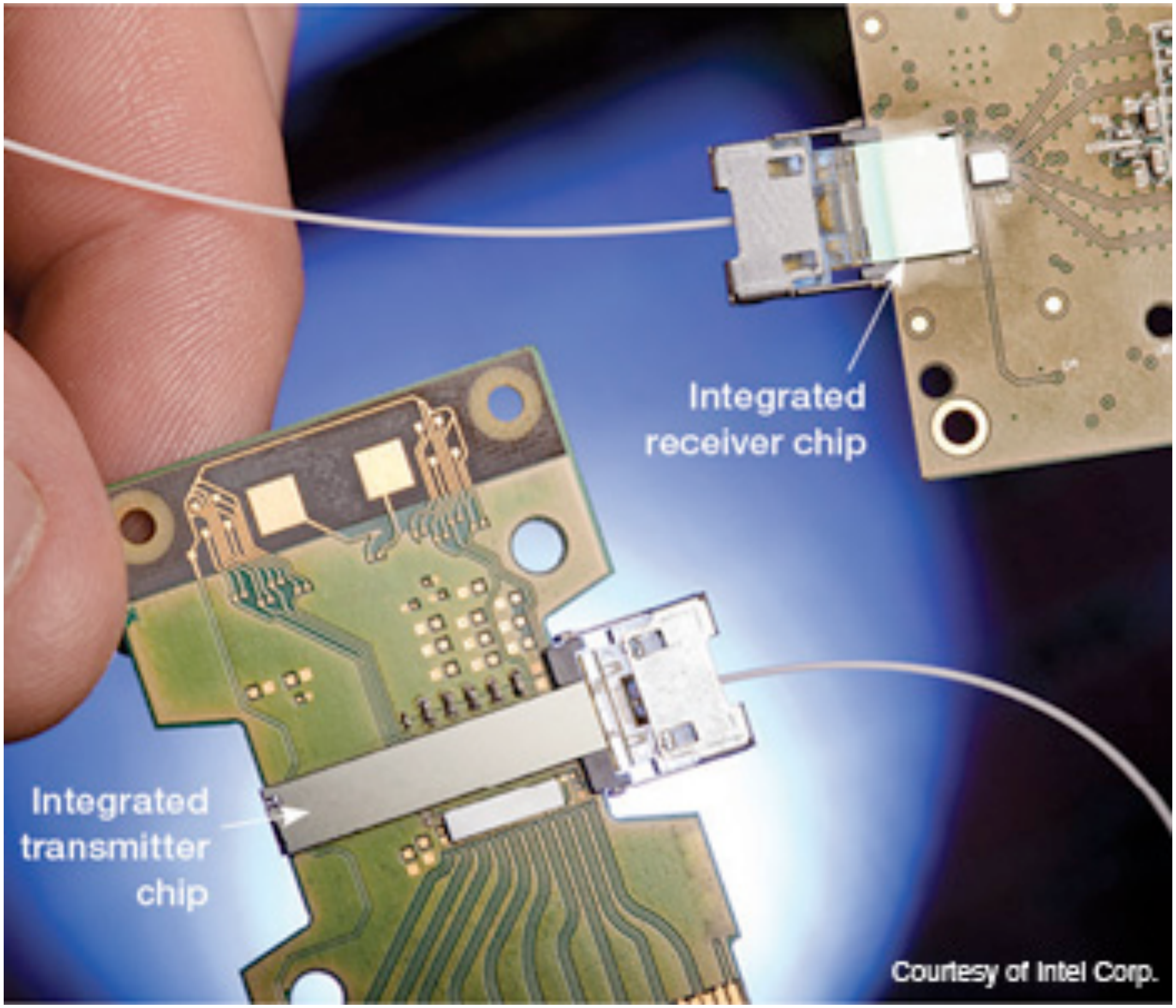
- Flat panel displays
  - PC, Tablet, TV, mobile devices, AR/VR head-mount displays
- High brightness LEDs
  - Solid state lighting, large display panels, automotive applications, LCD backlighting
- Imaging
  - Digital cameras, light field camera, 3D sensing
- Diode lasers
  - Data communications and telecommunications
  - Sensing
  - High power laser pumping source
- Renewable energy
  - Solar cells

Photonic Integrated Circuits (PIC) for Telecommunication Networks



Infinera

Silicon Photonic Links

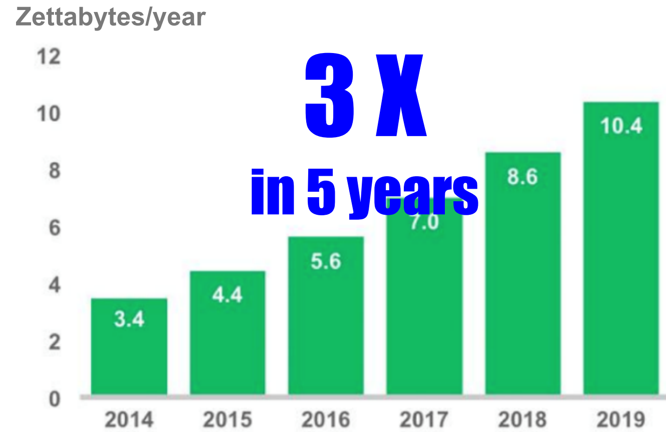


Internet and Data Centers

Every 60 Seconds

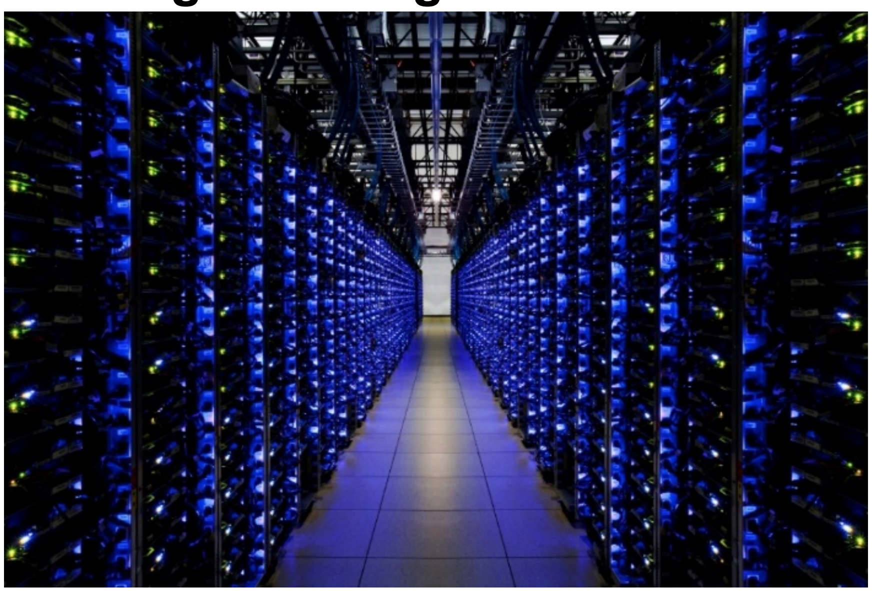
- **204 MILLION** Emails
- **5 MILLION** Google Searches
- **1.8 MILLION** "Likes"

Global Data Center IP Traffic Growth



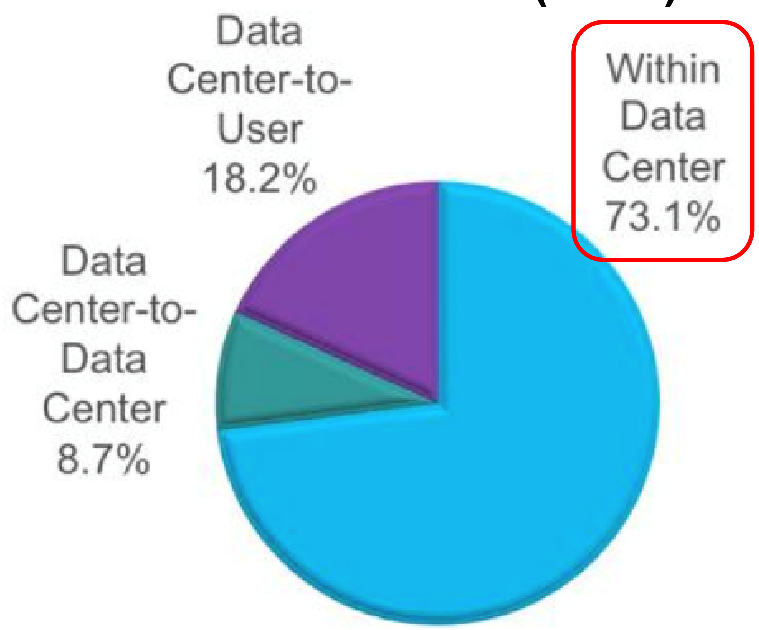
CISCO Global Cloud Index 2014-2019

Image of Google Data Center



http://www.google.com/about/datacenters/gallery

Data Center Traffic (2019)

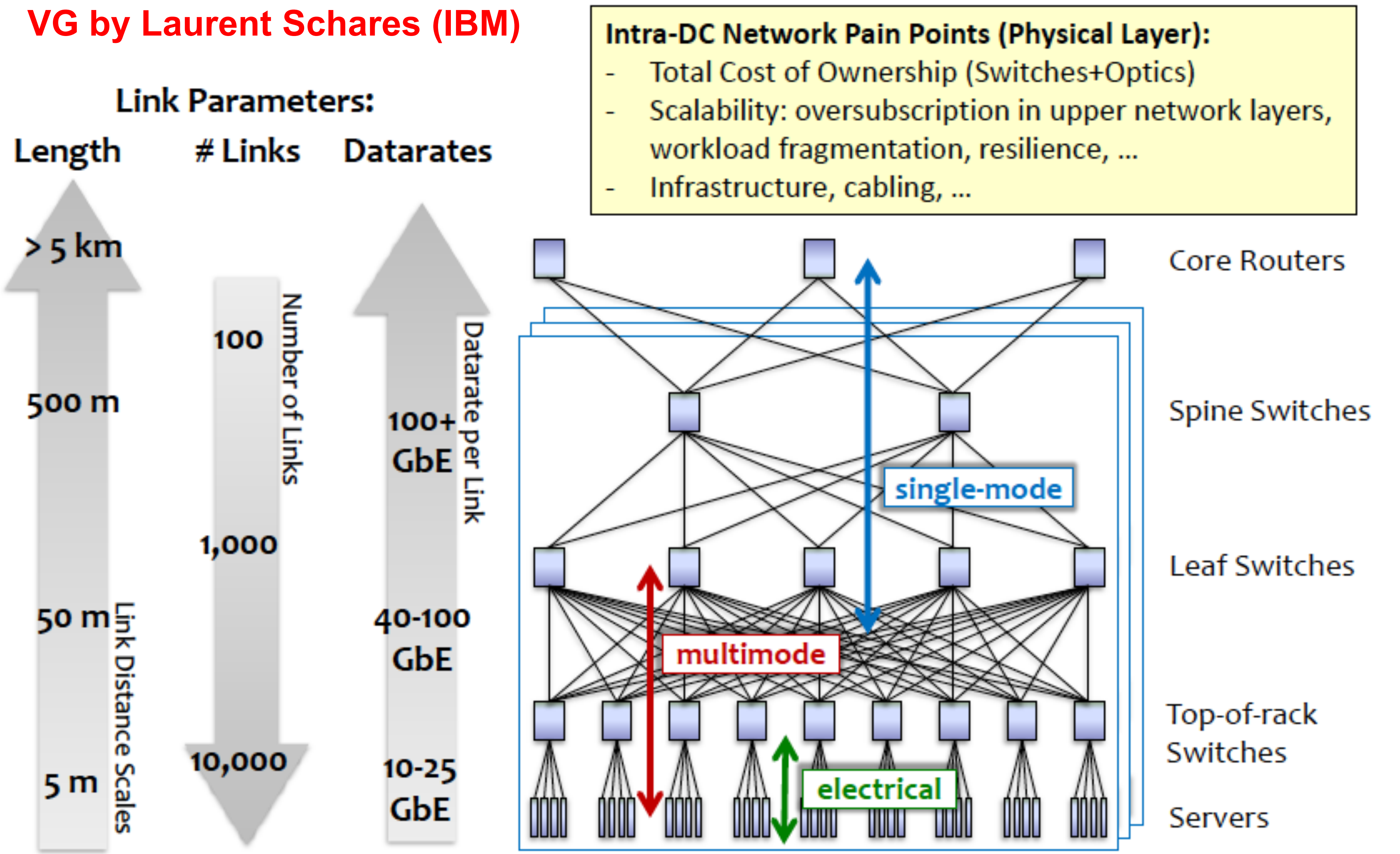


CISCO Global Cloud Index 2014-2019

Prof. Ming Wu

Generic Intra-Datacenter Network Model

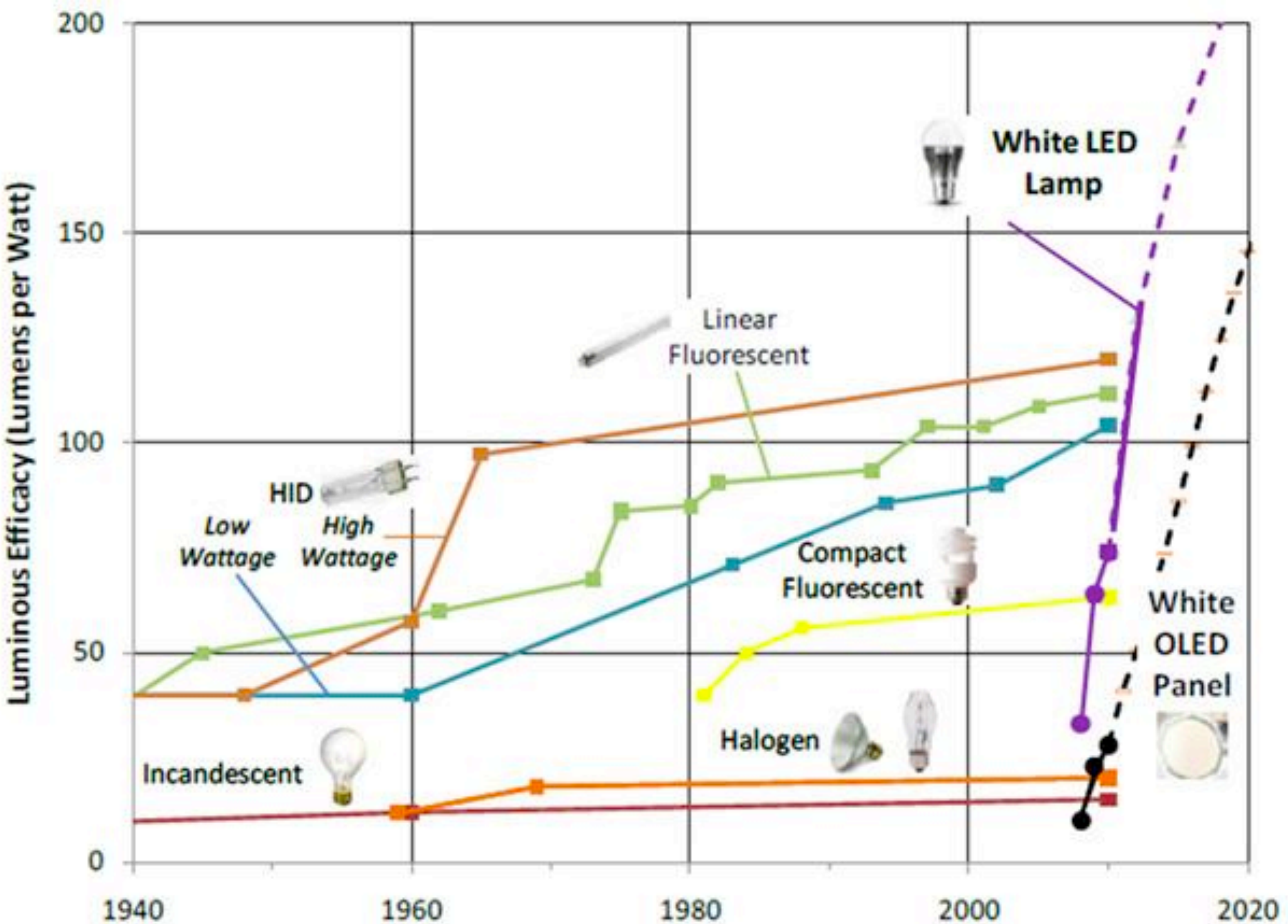
VG by Laurent Schares (IBM)



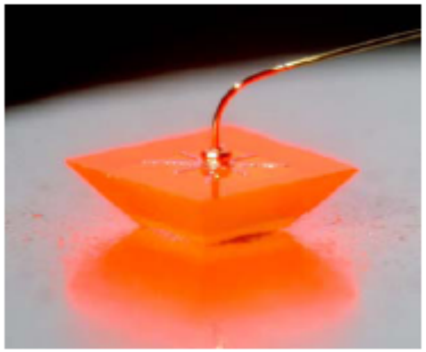
Generalized picture based on public information from a variety of datacenter operators

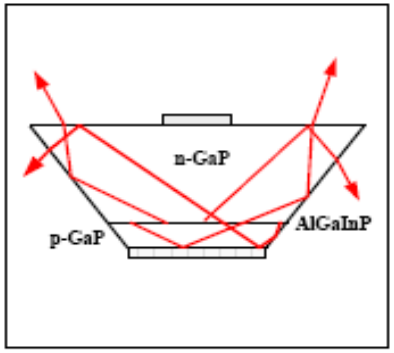
Data Centers come in all sizes. Just a few racks … to largest ones in the world:
~ 1 million square feet, ~ 100,000 servers.

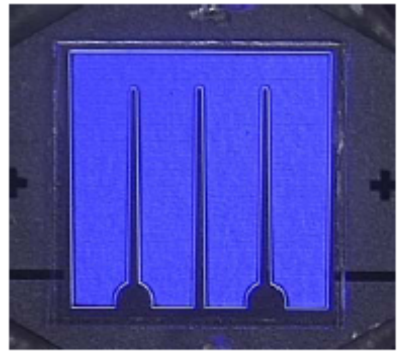
Evolution of LED Materials/Performances

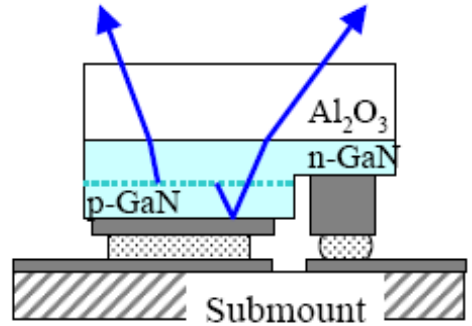


HB-LED Technology



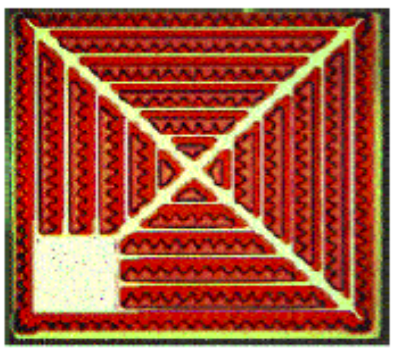


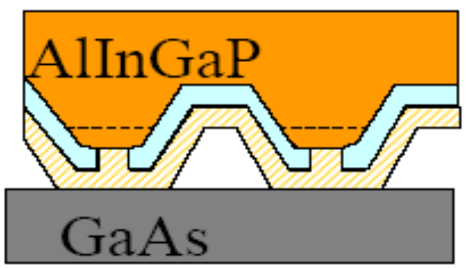


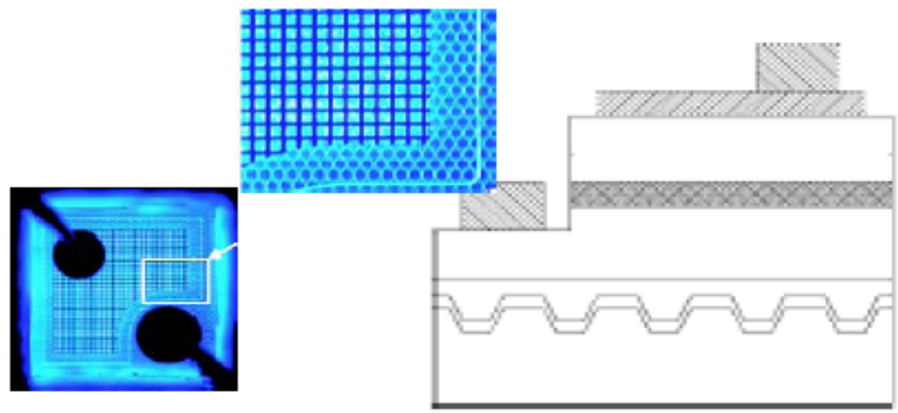


AlInGaN flip-chip (Lumiled)

AlGaInP/GaP truncated inverted pyramid (Lumiled)





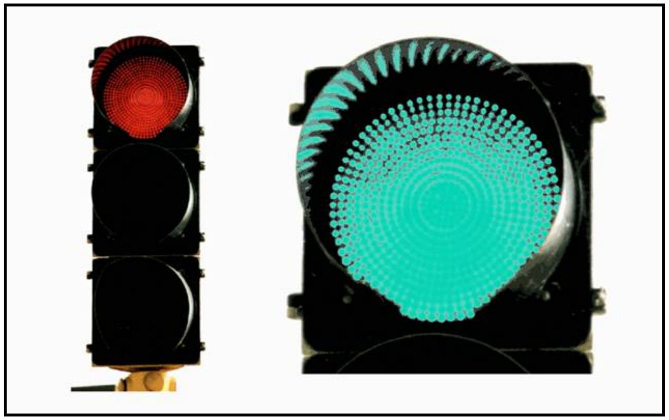


AlInGaP micro mirror (Osram),

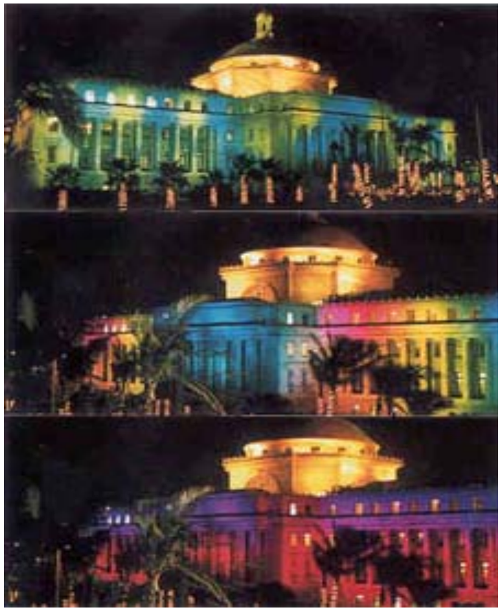
AlInGaN patterned substrate and mesh electrode (Nichia)

Source: LumiLeds

Applications of HBLEDs



Traffic Signals (inc white)



Source: http://www.northamericanlighting.com

Source: Toshiba (Technorainbow)

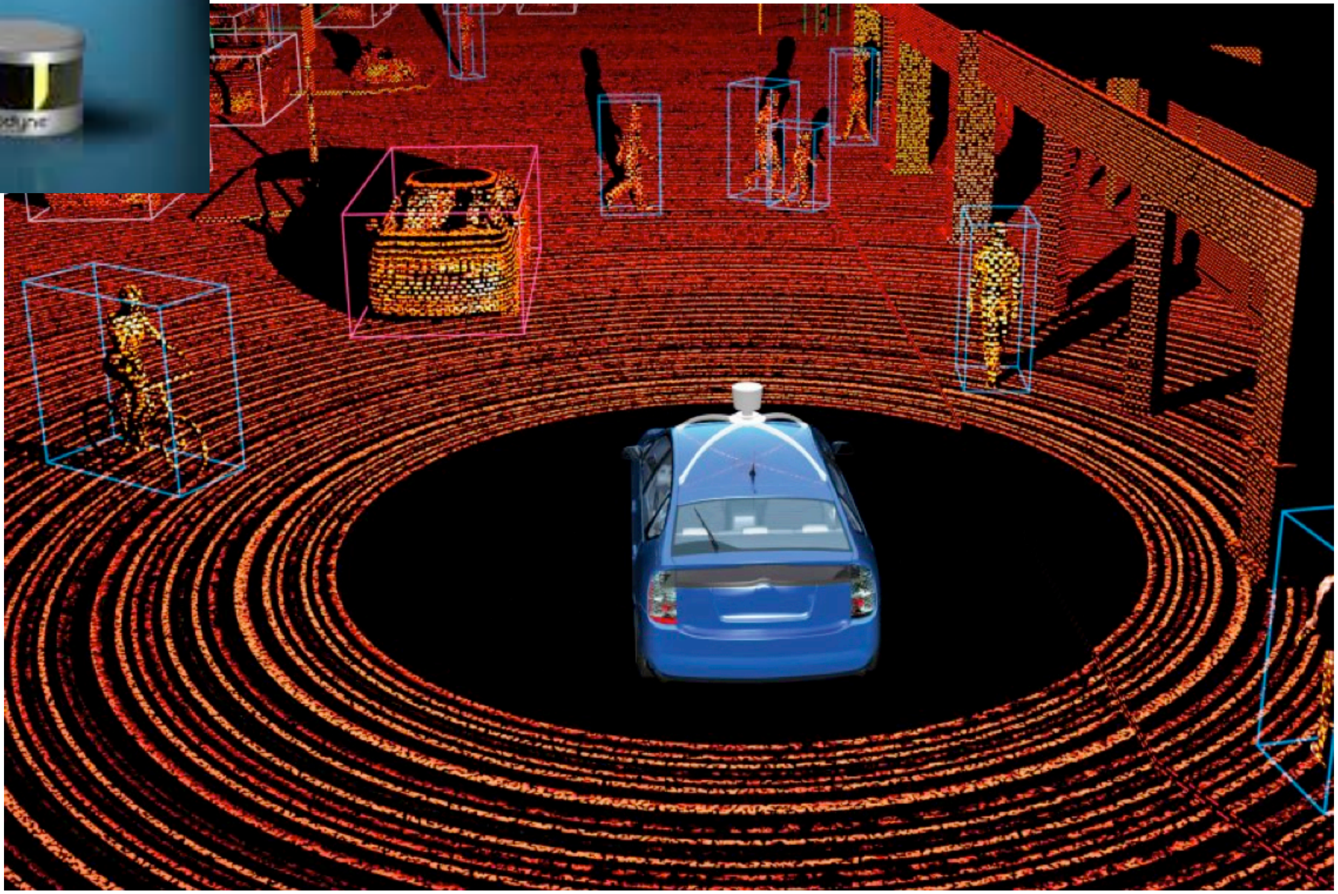
Outdoor lighting scenarios

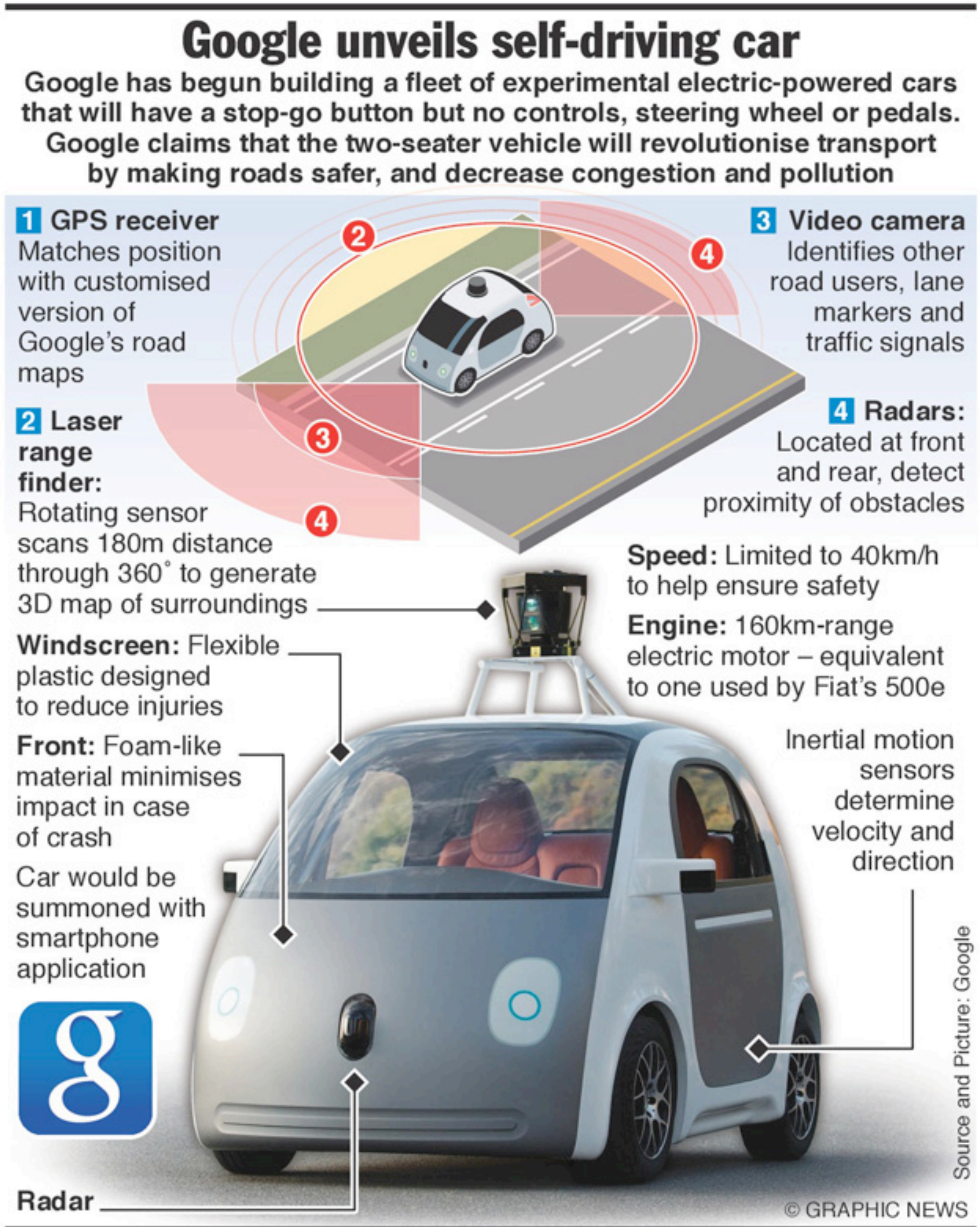
Source: Wustlich Design AG

Furniture Lighting

Architectural lighting

3D Imaging: Velodyne LIDAR




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 decrease congestion and pollution
1 GPS receiver
Matches position with customised version of Google's road maps
2 Laser range finder:
Rotating sensor scans 180m distance through 360° to generate 3D map of surroundings
3 Video camera
Identifies other road users, lane markers and traffic signals
4 Radars:
Located at front and rear, detect proximity of obstacles
Speed: Limited to 40km/h to help ensure safety
Engine: 160km-range electric motor – equivalent to one used by Fiat's 500e
Windscreen: Flexible plastic designed to reduce injuries
Front: Foam-like material minimises impact in case of crash
Car would be summoned with smartphone application
Inertial motion sensors determine velocity and direction
Radar
Source and Picture: Google
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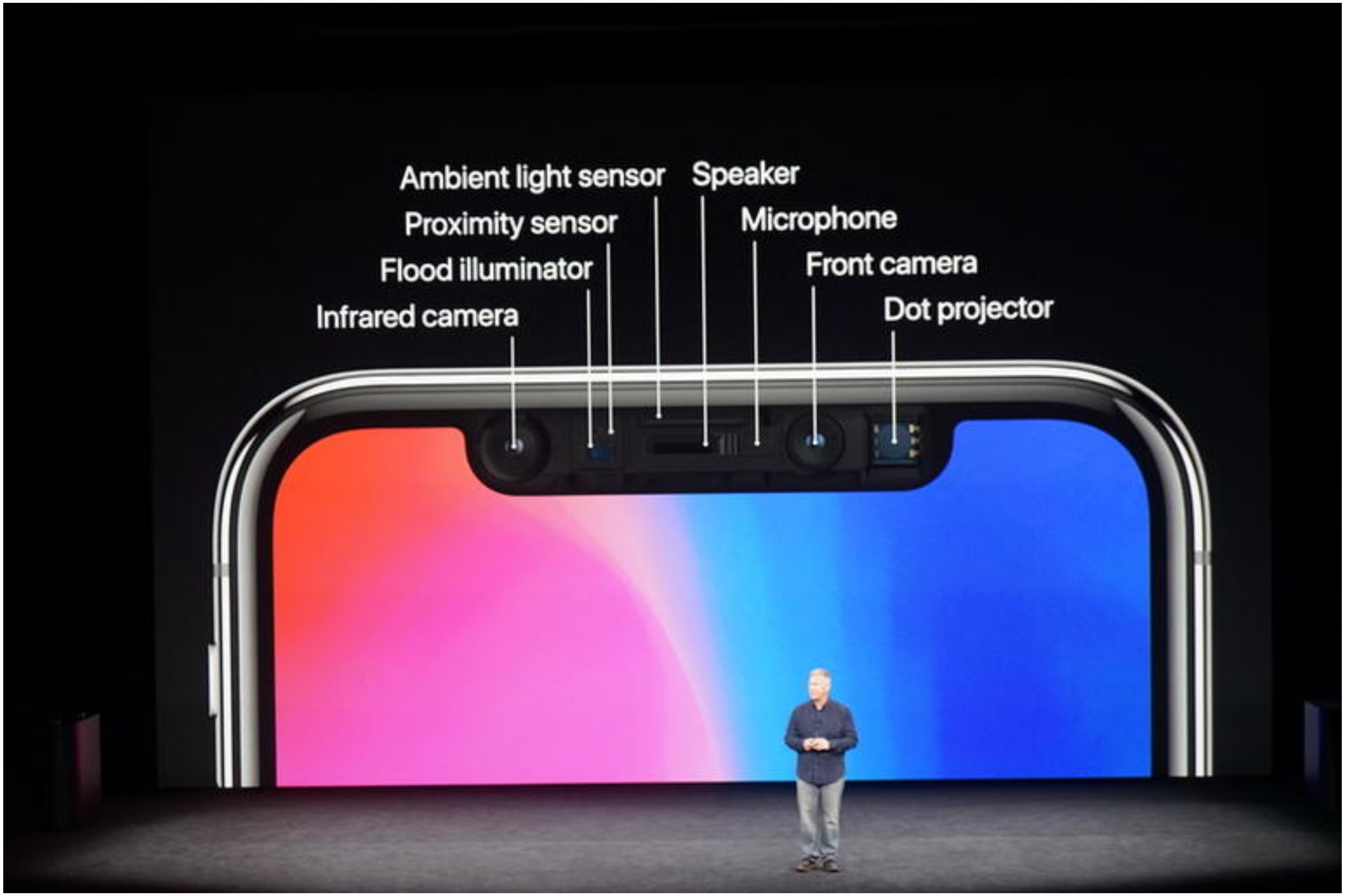
3D Imager in Mobile Devices



3D Imager with Structured Light Illumination