# Semiconductor Fundamentals

*Presented to*
*EE2187 class in Semester 1 2019/20*

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Indian Institute of Technology Hyderabad

*Lecture 1*

# Today's Class

- Introduce class details

  - Syllabus, schedule, grading & TAs

- Why this course?

- Brief History of Semiconductor Device

# Location and other detail

**Location**: Academic Block A: LH1

**Days/Times:** Monday, Wednesday and Thursday
900 hrs 1100 hrs 1000 hrs

**Course Title:** Semiconductor Fundamentals

**Credit:** 1

**Difficulty:** Medium

# Course Format

Lectures

Teaching Assistants: Hemant , Supraja, Ramesh, SaiMohan, Nirupam, Ullas, Diyam

Office hours: Free to come ( E-mail appointment)

Office location: Acd A, 609

# Course Objectives

To understand the fundamental of Semiconductor

- *Equilibrium Carrier concentration,*
- *Carrier transport*
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# Grading

- Quiz/HA 60%
- Final Exam: 40%

# Course information

- Semiconductors Materials - Types of Solids, Space lattice, Atomic Bonding,
- Introduction to quantum theory, Schrodinger wave equation, Electron in free space, Infinite well, and step potentials, Allowed and forbidden bands
- Electrical conduction in solids, Density of states functions, Fermi-Dirac distribution in Equilibrium,
- Valence band and Energy band models of intrinsic and extrinsic Semiconductors. Degenerate and non degenerate doping
- Thermal equilibrium carrier concentration, charge neutrality
- Carrier transport – Mobility, drift, diffusion, Continuity equation.

# Reference

## Text Book:


1. Physics of Semiconductor Devices, *S. M. Sze*, John Wiley & Sons (1981).
2. Solid State Electronics by *Ben G. Streetman and Sanjay Banerjee*, Prentice Hall International , Inc.
3. Semiconductor Physics and Devices, Donald A. Neamen, Tata Mcgraw-Hill Publishing company Limited.
4. Advanced Semiconductor Fundamentals by Pirret


## Reference Book:


1. Fundamentals of Solid-State Electronic Devices, *C. T. Sah*, Allied Publisher and World Scientific, 1991.
2. Complete Guide to Semiconductor Devices, *K. K. Ng*, McGraw Hill, 1995.
3. Solid state physics, Ashcroft & Mermins.
4. Introduction to Solid State Electronics, *E. F. Y. Waug*, North Holland, 1980.

# Have Questions?

- Quiz/HA 60%
- Final Exam: 40%

# Brief History……

Chapter :Origin and Personality of Microelectronics

Transistor: Fundamental for the integrated Circuit Engineer

RM Warner and BL Grung

(Wiley, New York)

# Technology with difference

As oppose to many other discoveries; in Semiconductor Technology,

Science come first,

Contributed equally by Scientist, Engineer and Inventor

Initially use to improve the communication Technology

# Brief History (Solid State Technology)

"Semiconducting" word First time use by Alessandro Volta in 1782

Intrinsic properties,( Faraday), Ag2S Resistance

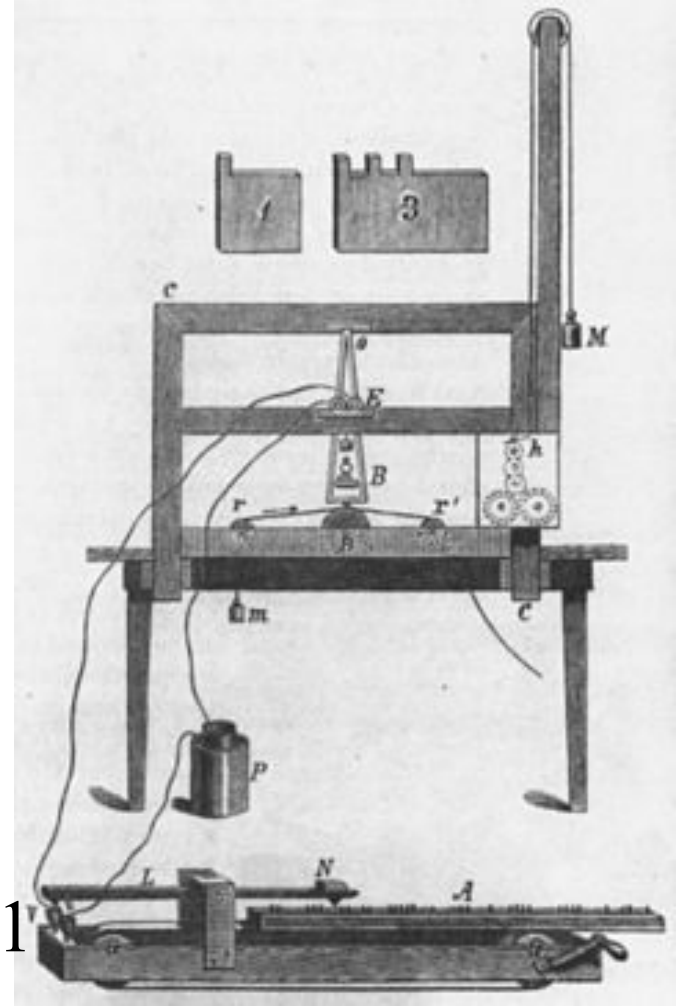
decreases with Temperatures , 1831

Morse (Telegraph) , 1833

(communication with single wire),

Photovoltaic effects at a junction between a semiconductor and an electrolyte (Becquerel), 1839

Quantitative analysis of the temperature dependence of the electrical conductivity of Ag2S and Cu2S Johann Hittorf , 1851



# Brief History (Solid State Technology)

Photoconductivity in in solids (Smith), 1874

Photovoltaic effects in solid by Adams and Day 1876,

Metal sulfides probed with a metal point leads : Rectifying properties

( Braun) 1874, Received Nobel prize 1909 , Further 1874 Arthur Schuster made Ckt. with Cu wire bound by screw observed effect only after some time not in use

Later used in radio and detection of microwave radiation in WWII radar

# Brief History……

First working solar cell was constructed by Charles Fritts in 1883 *(It consisted of a metal plate and a thin layer of selenium covered with a very thin layer of gold ),* The efficiency of this cell was below 1%

In 1878 Edwin Herbert Hall discovered that charge carri- ers in solids are deflected in magnetic field (Hall effect). *(used for to study the properties of semiconductors )*

JJ Thmoson and many scientist developed theory of conduction in metals

Eduard Riecke (1899) : First time propose a presence of both negative and positive charge carriers with different concentrations and mobility

JC Bose PbS point-contact rectifiers

1908 Karl Baedeker observed the dependence of the conductivity of copper iodide which indicated carriers with positive charge

# Brief History……

1914 Johan Koenigsberger divided solid-state materials into three groups with respected to their conductivity

In 1904 J. C. Bose obtained a patent for PbS point-contact rectifiers

G. Pickard was the first to show that silicon point-contact rectifiers were useful in detection of radio waves (patent in 1906)

The selenium and copper oxide rectifiers were developed, respectively, in 1925 by E. Presser and 1926 by L. O. Grondahl

The selenium rectifiers were heavily used in the WWII in military communications and radar equipment

# Brief History……

- Field effect phenomenon discovered independently by J.E. Lilienfeld (in US) and O. Heil (in UK) in the late 1920s.
- Commercialization did not happen until 1960 (D. Kahng and M. Atalla).
  - Main reason: Because of the poor semiconductor-insulator interface
  - Development in MOSFET overtaken by the BJT
- Since then, it has revolutionized the electronics industry for 6 decades (and is going strong).
- Mainstream technology for VLSI era and now the ULSI era.
- Very scalable;
  - 22 nm technology already in production
  - 14 nm technology already in production
  - 7 nm technology under development

# Summery