EE2003 – SEMICONDUCTOR FUNDAMENTALS (*Part I*)

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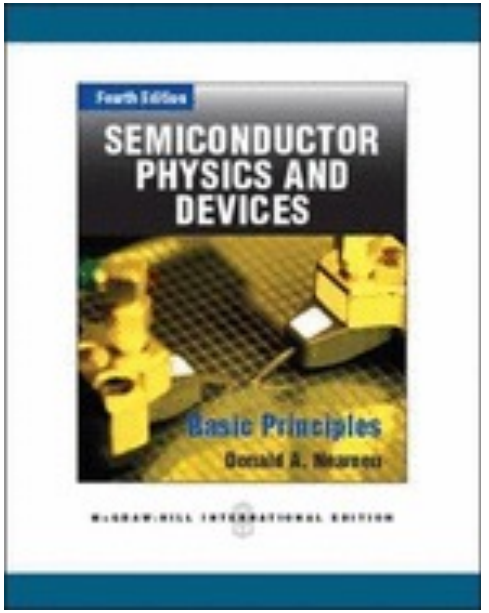
Lecture notes & tutorial questions are available in NTULearn

Textbook

D. A. Neamen, **Semiconductor Physics & Devices – Basic Principles**, 4th Ed., McGraw Hill, 2011.



Other Reference Books:

- B. G. Streetman and Sanjay Banerjee, **Solid State Electronic Devices**, 5th Ed., Prentice-Hall, 2000.
- R. F. Pierret, **Semiconductor Devices Fundamentals**, 2nd Ed., Addison Wesley, 1996.
- C. Hu, **Modern Semiconductor Devices for Integrated Circuits**, 1st Ed, Prentice Hall, 2009.
- R. F. Pierret, **Advanced Semiconductor Fundamentals**, 2nd Ed, Prentice Hall, 2002.

Tutorials (Extended)

- Please attempt all questions prior to tutorial class. We will have discussion in the tutorial classes;
- Please go to your respective tutorial groups, check the day / time / room;
- The first tutorial starts in Week #1;

Grading

- Continuous Assessment (CA): 40%
  - Mid-term Quiz: 10%
  - Class Participation: 10%
  - Homework Assignment: 10%
  - Practical Work (L2003A, L2003B): 10%
- Final Exam: 60%

Updated details are made available at the beginning of every semester in the course announcement.

Examination Matters

There will be **4 questions** and you are required to answer **all** questions in 2.5 hrs.

Date: *To be announced.*

Selected formulae & **table of physical constant** will be given in the **Appendix** of the exam script.

Past year papers: EE2003 are available from the library.

* *Details are available in the course announcement*.

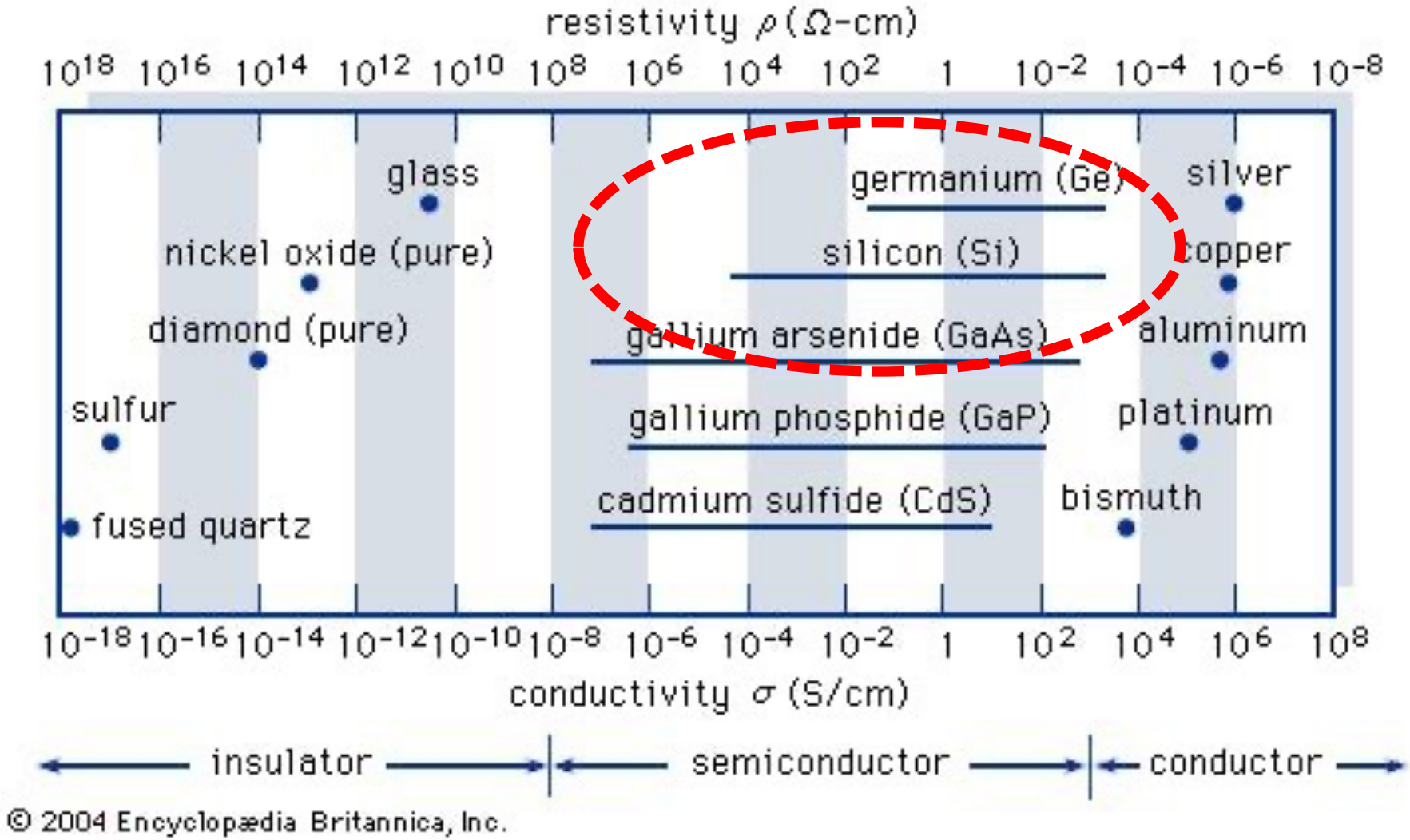
Examination Topics

For **Part I** of the lecture, the following topics are **NOT** included in the examination.

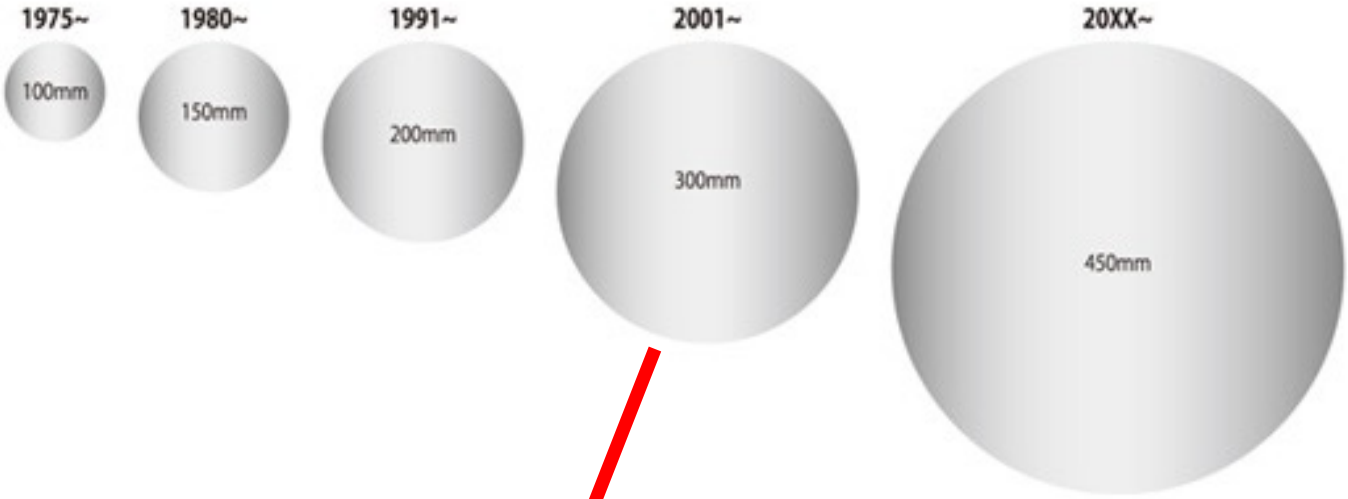
- Bonding of hydrogen molecules (section 3.1)
- Topics in the Appendices. However, you need to know the concepts in the Appendices to understand the course.

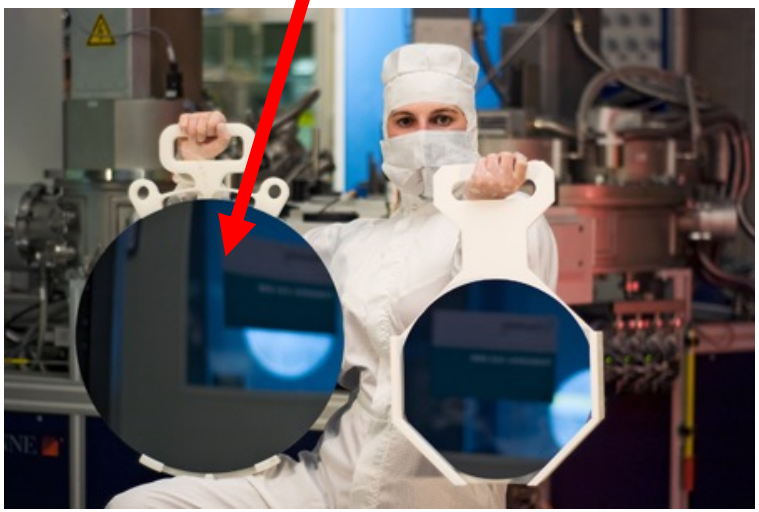
  For examples: electronic configuration of atoms in Appendix A, *k* wavevector in Appendix D, effective masses m_n^* & m_p^* in Appendix E.

Material Conductivity

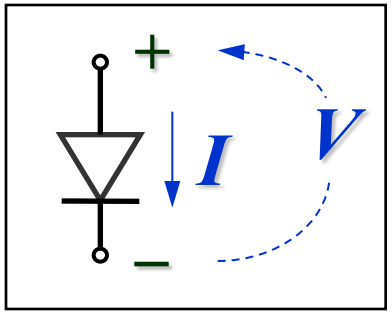


Silicon Wafer Size





What is this course about?



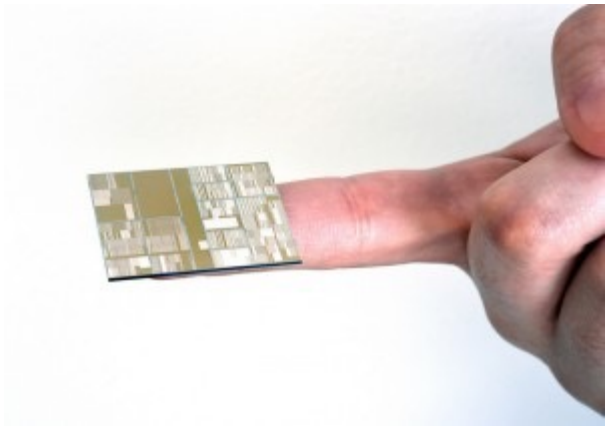
How many transistor do you think you carry with you in your laptop/tablet/smart phone today?

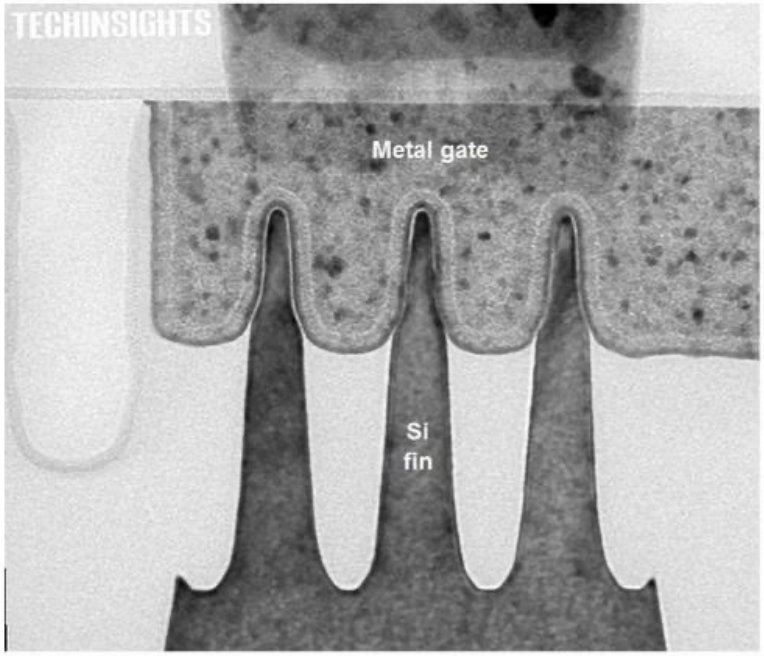
(a) 1K

(b) 1M

(c) 1B

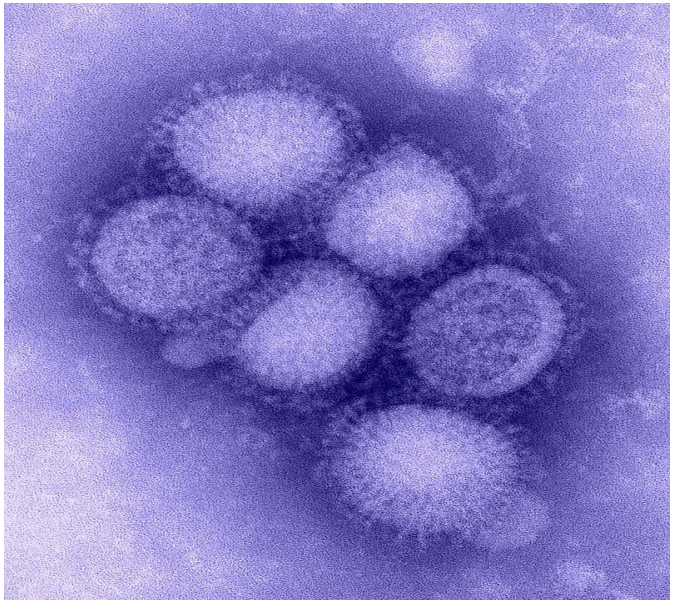
(d) 1T



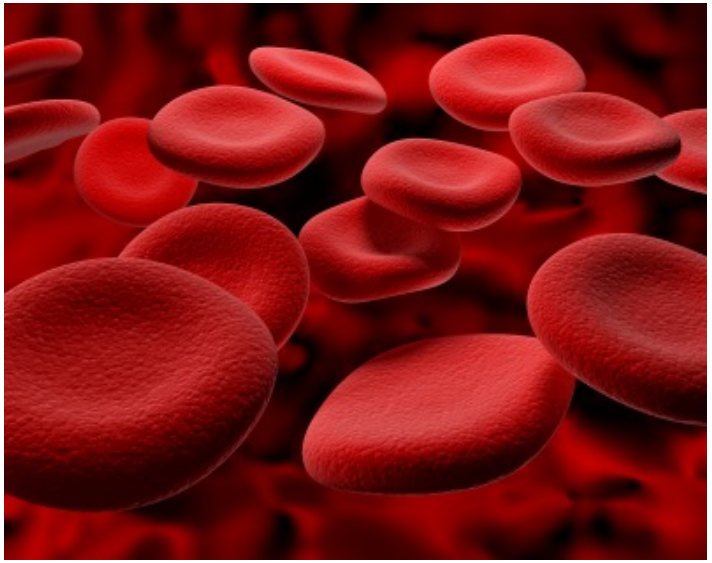


State-of-the-art transistor: 14 nm (intel)

H1N1 Virus: 100 nm (7x)

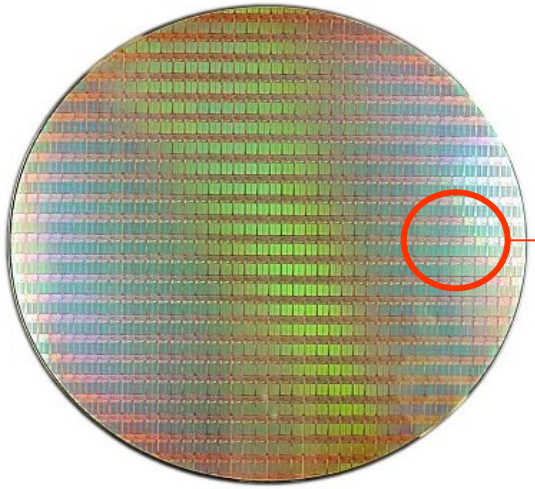


Red Blood Cell: 7,800 nm (550x)

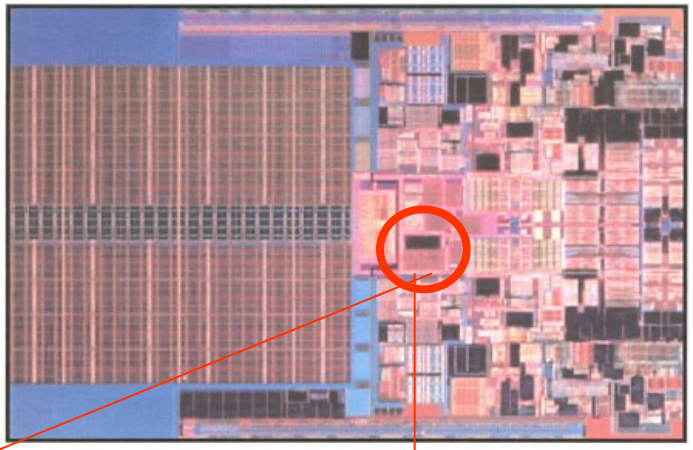


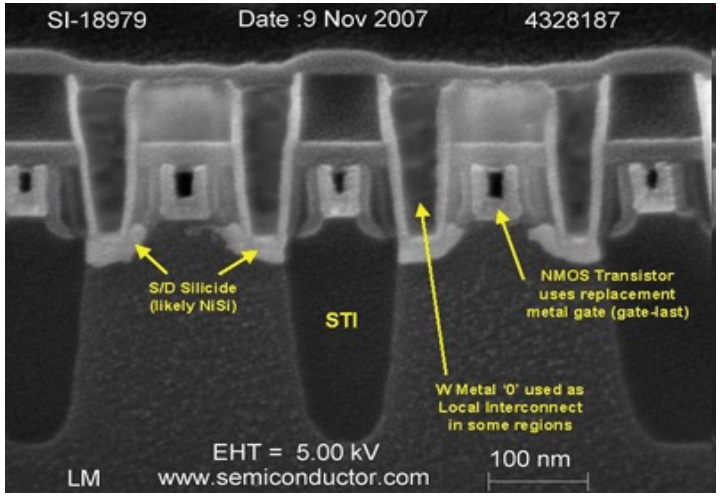
Intel Penryn (and Nehalem) 45 nm Core 2 Duo

12” Processed Wafer

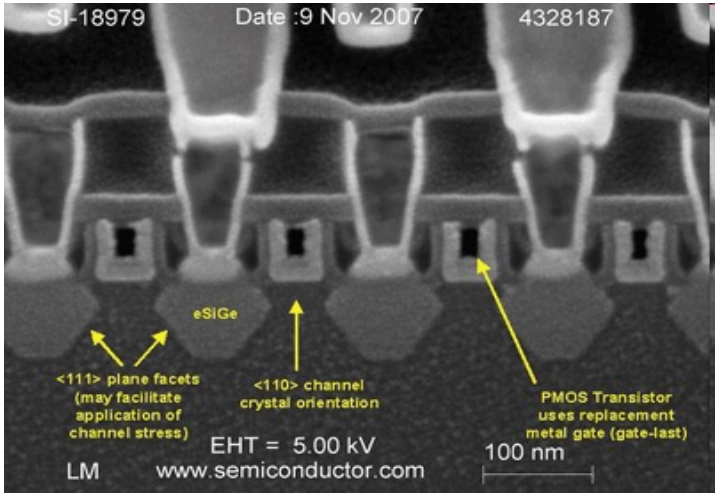


Penryn Die Photo



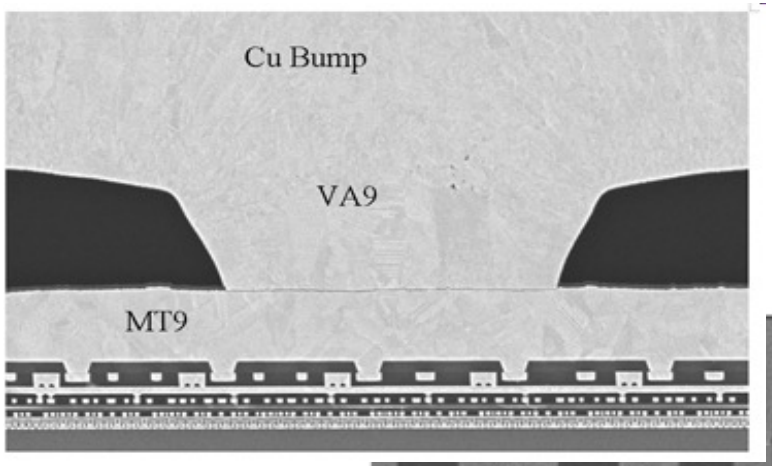


NMOS

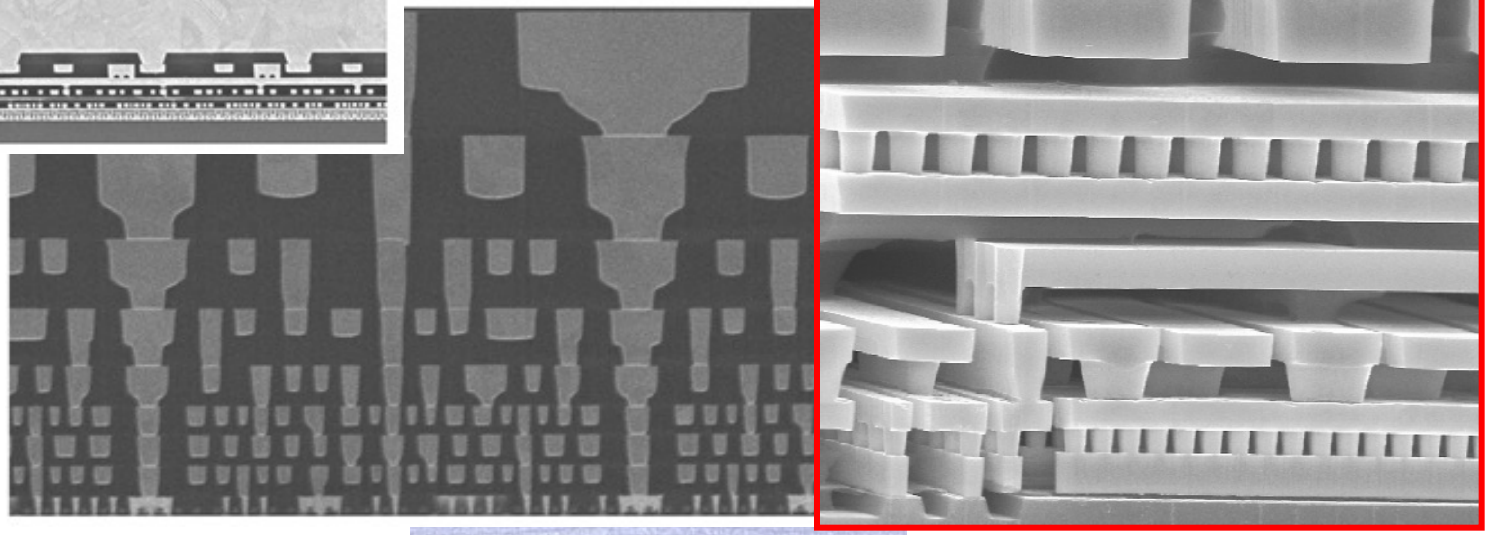


PMOS

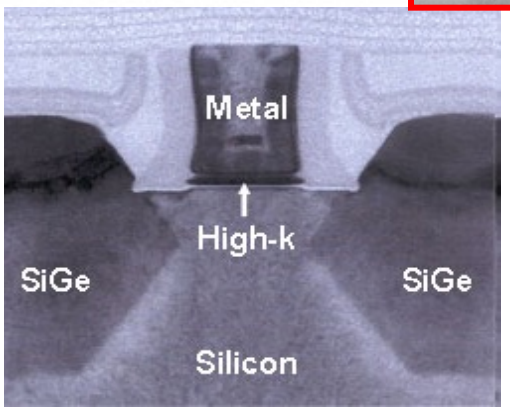
Dissection of Intel IC Chip



Solder Bump - Packaging



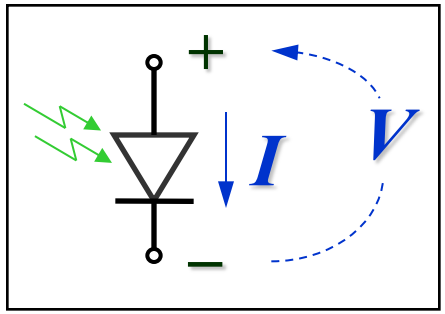
Multi-level Interconnects - BEOL

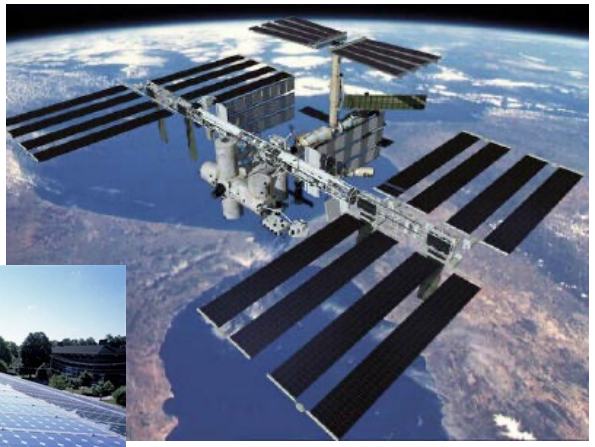


Transistors - FEOL

Intel Technology Journal, 2008

When light is involved…





Contents (Part I)

4. Doping of Semiconductors

i. Intrinsic material

ii. Impurities in semiconductor: Donor & Acceptor

5. Semiconductor in Equilibrium

i. Fermi-Dirac Distribution Function

ii. Density of States

iii. Thermal Equilibrium Carrier Concentrations

iv. Intrinsic & Extrinsic Materials

6. Carrier Transport

i. Thermal Motion

ii. Drift Current

iii. Diffusion Current

iv. The Einstein Relation

Appendices

A. Atoms & Atomic Bonding
B. Density of States
D. E–*k* Relation
E. Effective mass
F. Characterization *(useful for labs)*

Where is EE2003 taking you to?

EE1003 INTRODUCTION TO MATERIALS FOR ELECTRONICS

⇩

EE2003 SEMICONDUCTOR FUNDAMENTALS

⇩

EE3013 SEMICONDUCTOR DEVICES AND PROCESSING
EE3018 INTRODUCTION TO PHOTONICS

⇩

FINAL YEAR SPECIALIZATION

Microelectronics

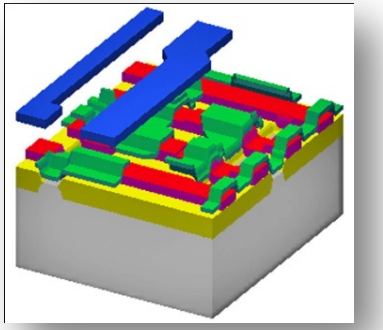
Design Electives

EE4613 CMOS Process and Device Simulation by Technology CAD

- *Workstation Based Design & Simulation Course*
- *Virtual Wafer Fabrication & Device Characterization of a 2 μm CMOS Process*
- *Virtual Process Integration for MOS Technology Development & Device Optimization*

EE4614 Device Parameter Extraction & Layout Implementation

- *Workstation Based Design & Simulation Course*
- *Virtual Device Characterization*
- *Transistor Parameter Extraction*
- *Circuit Simulation & Mask Layout*



Microelectronics

Technical Electives

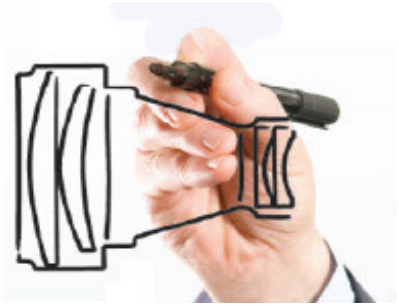
EE4645	Microfabrication Engineering
EE4646	VLSI Technology
EE4647	Microelectronic Devices
EE4648	Flat Panel Display Technologies
EE4694	IC Reliability and Failure Analysis
EE4695	Semiconductor Physics

Photonics

Design Electives

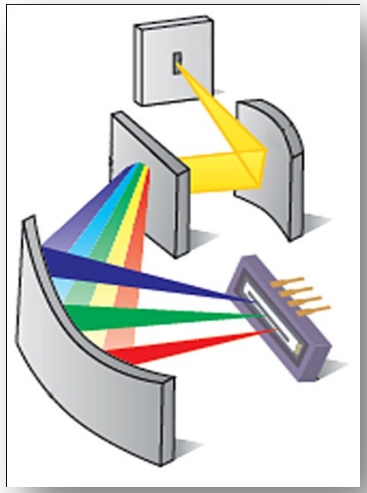
EE4815 Optical Design

- *Design of multiplayer dielectric films and lasers, are the two widely used technologies of optics.*



EE4816 Photonic Devices: Design and Characterization

- *Principle & advanced techniques related to photonic operation, design & characterization, & their implementation in photonics systems.*



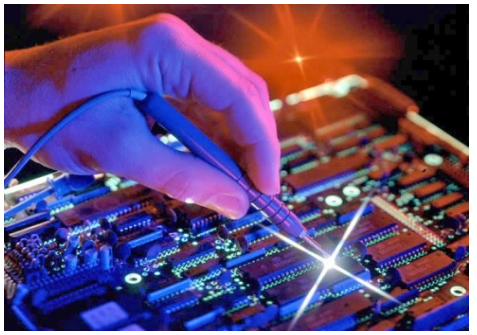
Photonics

Technical Electives

EE4648	Flat Panel Display Technologies
EE4695	Semiconductor Physics
EE4836	Semiconductor Optoelectronics
EE4838	Laser Engineering and Applications
EE4839	Fibre Optic Communications
EE4840	Biophotonics

Electronics Sector in Singapore

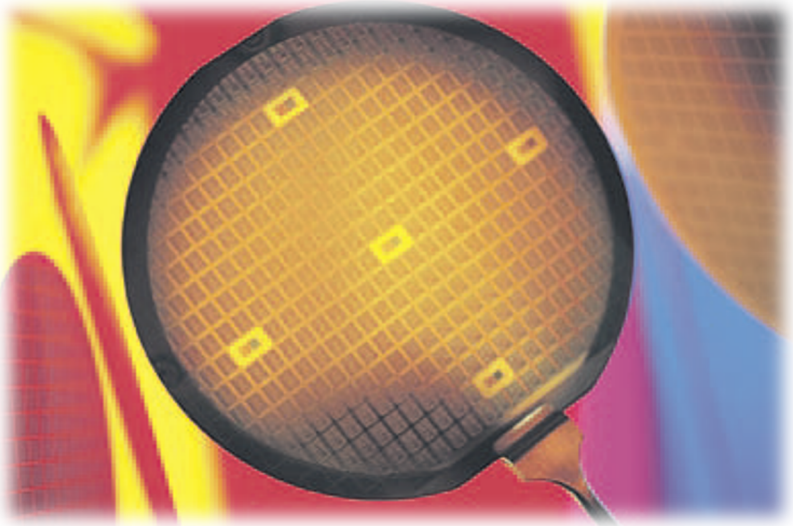
- Electronics is the major industry underpinning Singapore's economic growth.
  - ➔ ***contributes 31.5% of the city-state's manufacturing output.***
- In 2009, electronics accounted for almost 41.5% of the total S$11.8 billion in fixed asset investments.
- Employment for the industry in 2009 stands at 76,000, which is 19% of total manufacturing jobs.



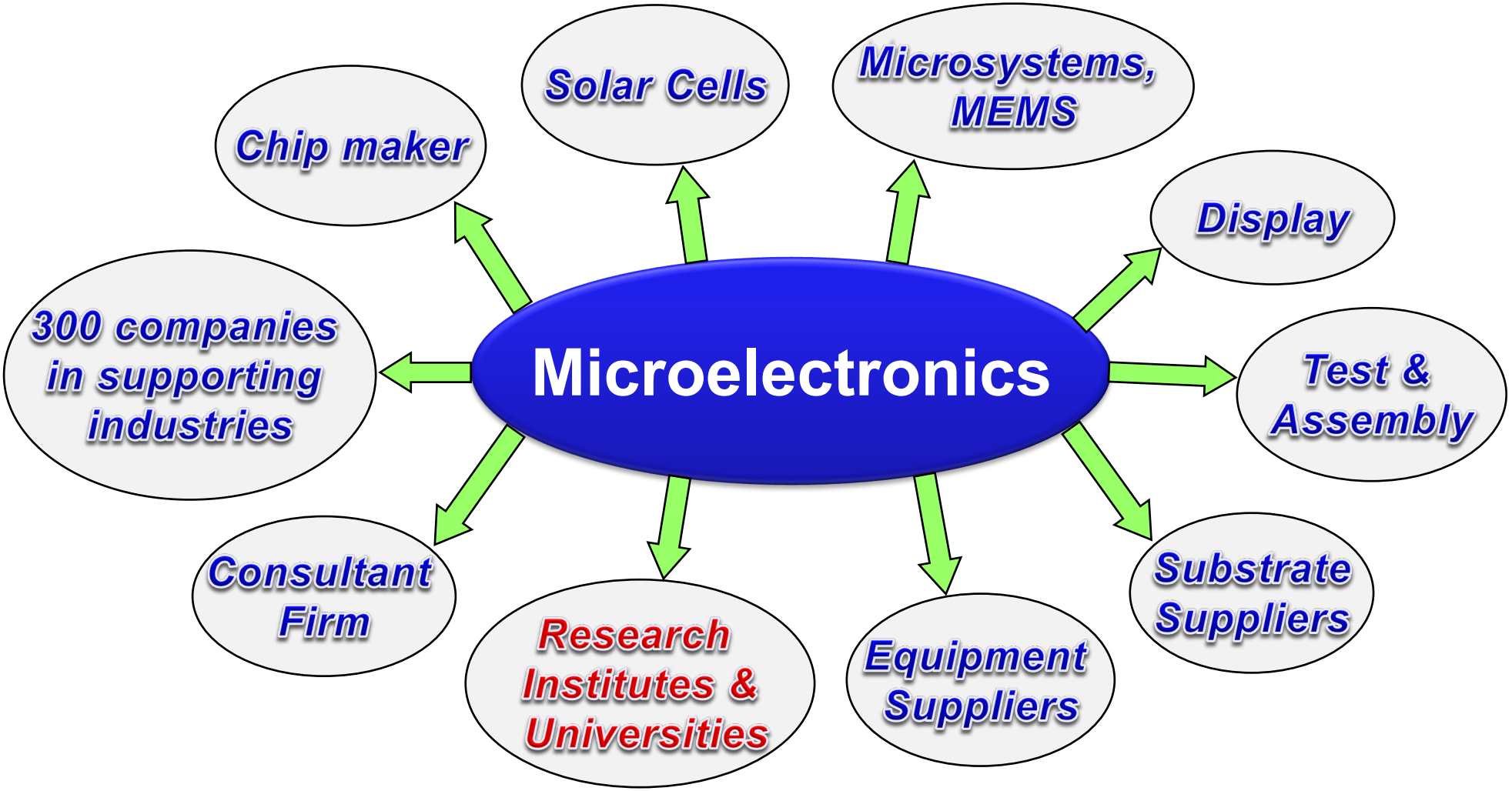
EDB singapore

Microelectronics Industry in Singapore

- **14** Si wafer fabrication plants.
  - ➔ *world's top three wafer foundries, 500,000 wpm, 10% of global foundry wafer capacity, three 300mm fabs.*
- **5** compound semiconductor fabrication plants.
- **20** semiconductor assembly & test operations.
  - ➔ *3 of the world's top 5 outsourced semiconductor assembly & test companies*

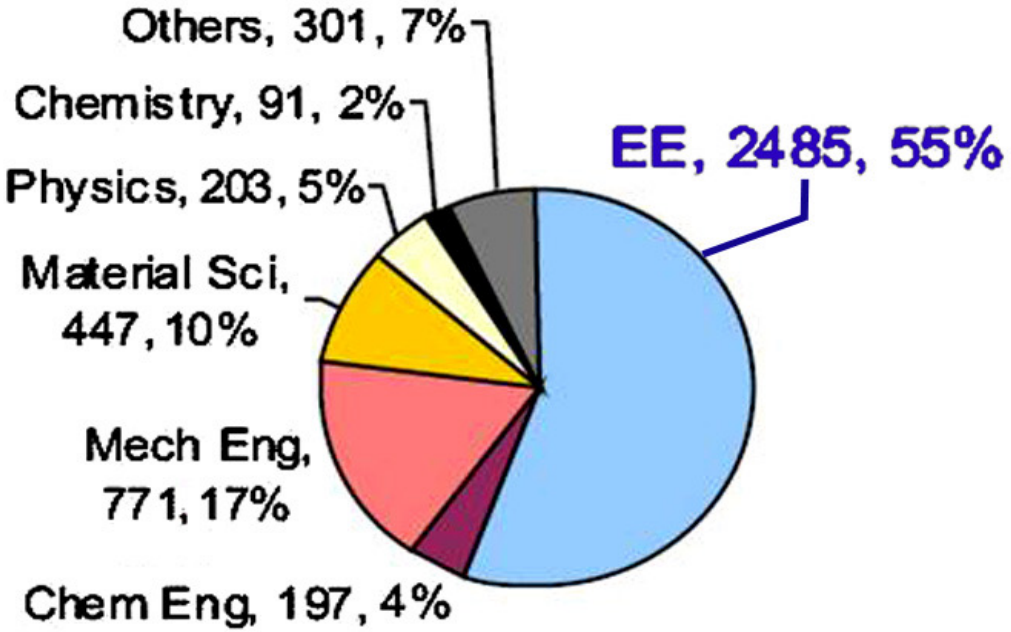


Job Opportunities



A Broad Spectrum of Job Opportunities across the Value Chain!

Breakdown of Manpower Demand



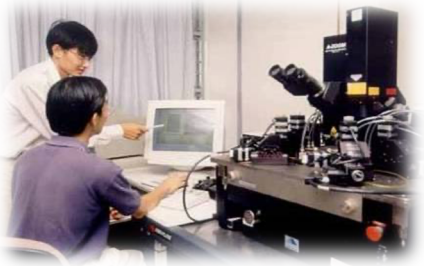
Current Wafer Fab Profile by Discipline
(Bachelors and above)

Sector	Average Demand Per Year (Degree and above)
Wafer Fab	1,112
HDD	160
A&T	231
IC Design	276
Total Electronics	1,779

EDB singapore

Research Oriented Opportunities

- Professors EEE are research active.
  - ➔ *~25% of EEE graduate students are studying Microelectronics*
- Many PhD scholarships.
- Job prospect after MEng or PhD: Professor, research scientist or engineer at IME, IMRE, DSI, I2R, SimTech, IBN, NTU, NUS, etc. (& overseas opportunities).



Check out the following YouTube clips….

From sand to chip - How a CPU is made

How do they make Silicon Wafers and Computer Chips?

Semiconductor Technology at TSMC, 2011

What are your expectations of this course?