Course contents

ELEC-E8410 Materials in Energy Applications

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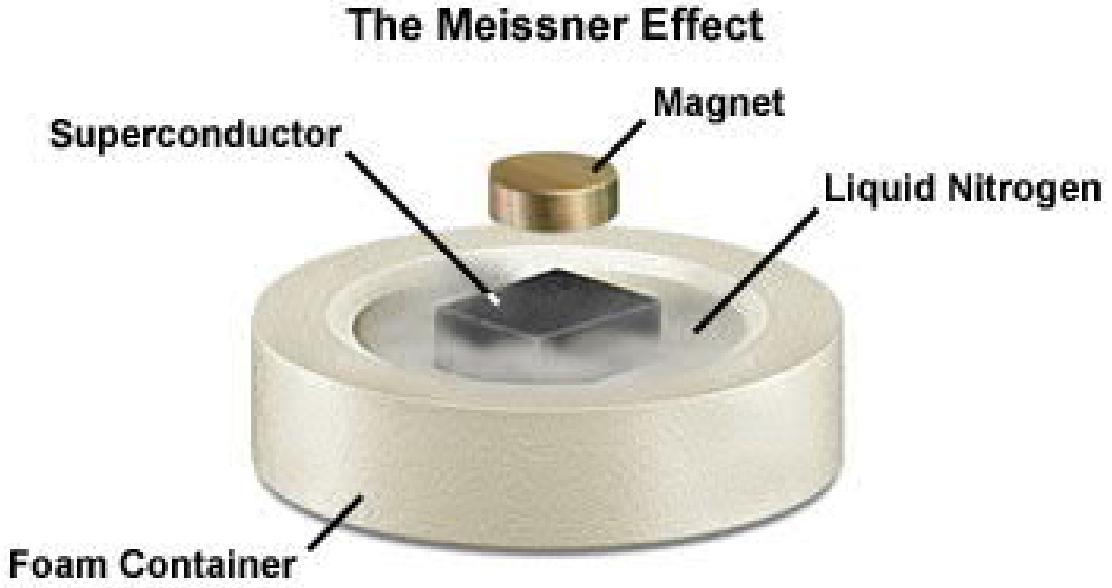
- Introduction about materials
- Electromagnetic fields
- Magnetic materials
  - Soft magnetic materials
  - Soft Magnetic Composites
  - Permanent magnets
- Electric field and related materials
  - Piezoelectric materials
  - Insulators
- Superconductivity and its applications



https://nationalmaglab.org/images/education/magnet_academy/learn_basics/articles/superconductivity/superconductivity-meissner.jpg

Course outcome

At the end of the course you will be able to:

- Explain the behavior of materials for electrical engineering
- Understand the field-material interaction
- Develop models of soft and hard magnetic materials
- Explain how materials affect the operation of electrical devices
- Account for material properties in the design of electrical devices
- Understand the operation of some innovative electrical devices

Practical issues

- The course material is based on different sources
  - Most of the course is based on the lecture slides
  - Some additional literature will be given during the lectures
- All the course related material will be in MyCourse
- The course does not have an exam.
- To complete the course you need to:
  - Solve and return the exercises (40% of grade)
  - Successfully make and return the assignments (2 assignments, 40% of grade)
  - Actively participate in the group works during the lectures (20% of grade)
  - You get 2 additional point by answering the student feedback survey
- It is very recommended to participate in the lectures

Brain storming

- Take 10 min and think of what materials are related to energy application
- Write down these materials, we will compile the results during the lecture

- List of materials:
  - Metals (iron steel aluminum, copper, magnets, metal alloys)
  - Fuels Carbon (coal) Hydrogen (fuel) oil gas
  - Air(wind energy) water (hydro generation / cooling)
  - Semiconductor (silicon-based -- > solar and Power Electronics)
  - Insulators (epoxy, oil, air, paper, plastics and rubber)
  - Battery applications (lithium, lead)
  - Uranium and other nuclear fuels, Helium, plutonium)

Materials according to their atomic bonding

- Metals

  valence electrons are detached from atoms, and spread in an 'electron sea' that "glues" the ions together. Strong, ductile, conduct electricity and heat well, are shiny if polished.

- Semiconductors

  the bonding is covalent (electrons are shared between atoms). Their electrical properties depend strongly on minute proportions of contaminants. Examples: Si, Ge, GaAs.

- Ceramics

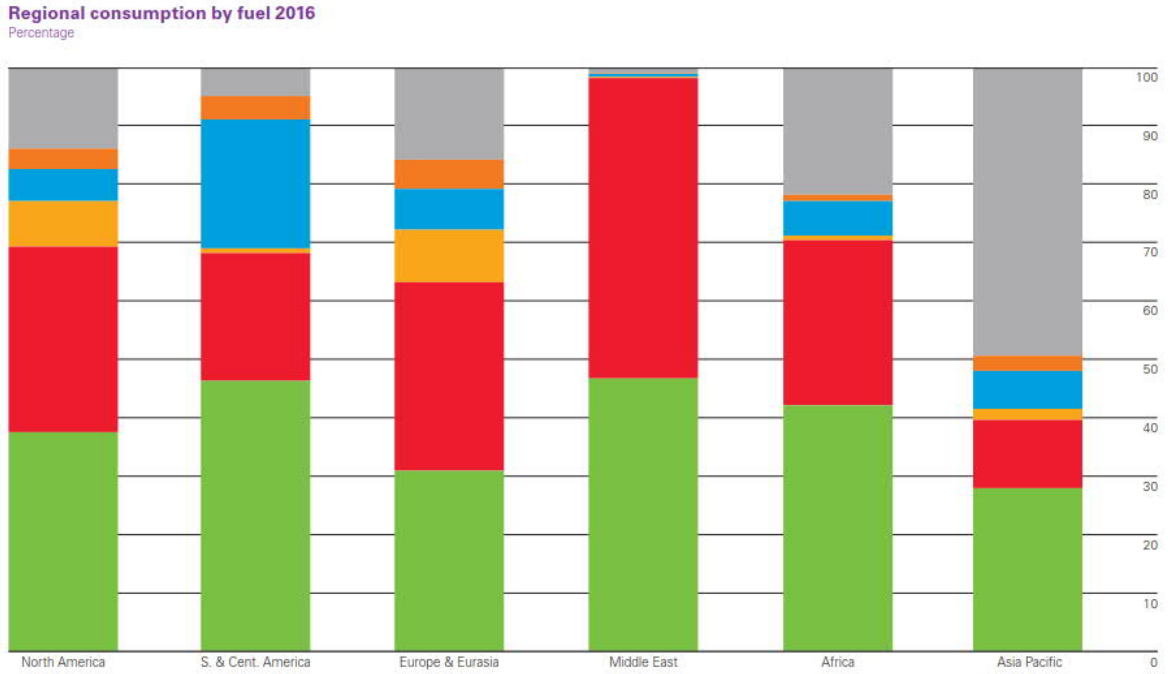
  atoms behave like either positive or negative ions, and are bound by Coulomb forces. They are usually combinations of metals or semiconductors with oxygen, nitrogen or carbon (oxides, nitrides, and carbides). Hard, brittle, insulators. Examples: glass, porcelain.

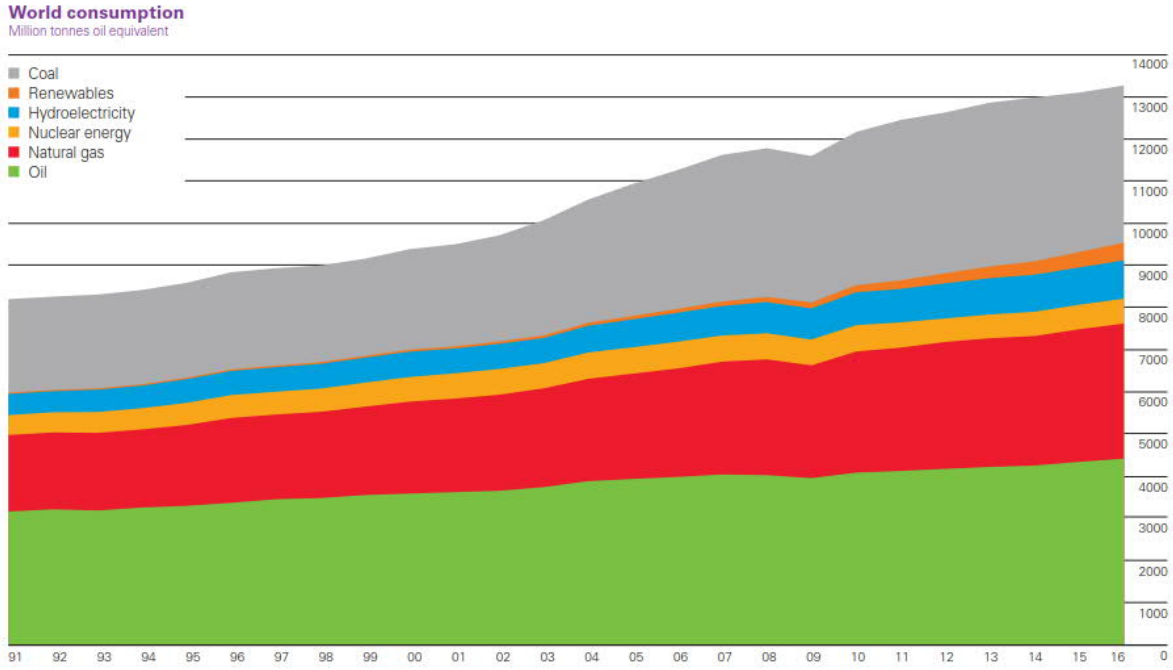
- Polymers

  are bound by covalent forces and also by weak van der Waals forces, and usually based on C and H. They decompose at moderate temperatures (100 – 400 C), and are lightweight. Examples: plastics rubber.

Fuels

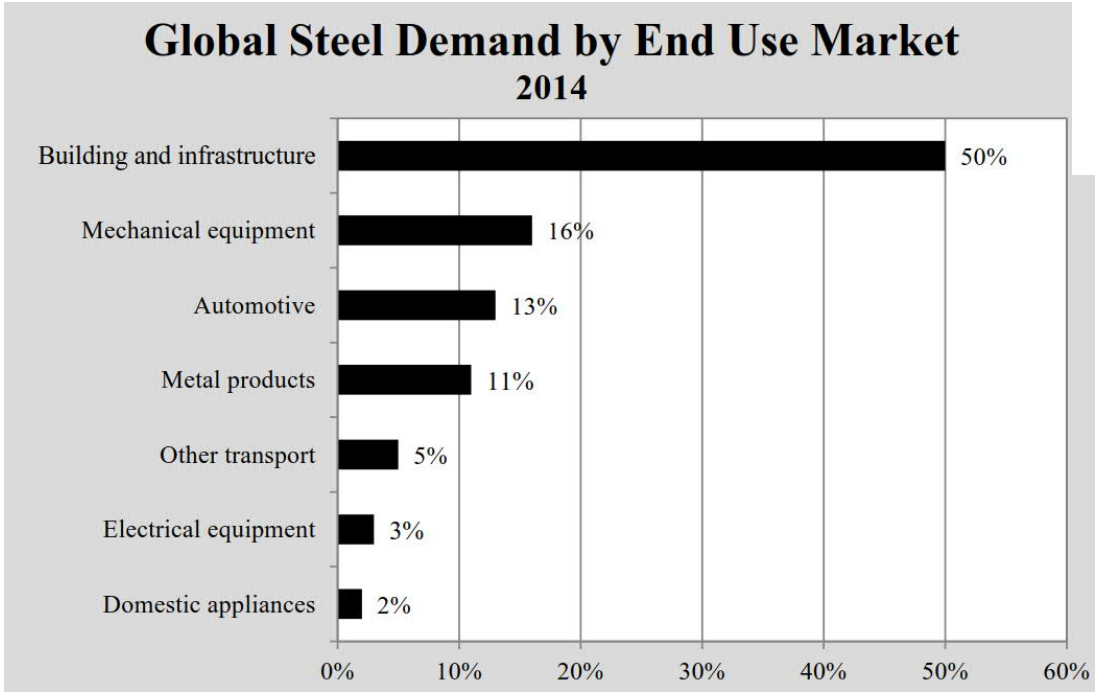
- Thermochemical materials
  - fossil fuels and bio-fuels
    (oil, natural gas, ethanol, biodiesel, etc)
- Thermonuclear materials
  - uranium-235, plutonium-239
- Fuels for space and military applications
  - Solid, liquid, and gas fuels
  - Liquid Oxygen
  - Liquid Hydrogen
  - Kerosene
  - Nitrogen tetroxide (N2O4)
  - Hydrazine (N2H4)
  - APCP (Ammonium perchlorate composite propellant)

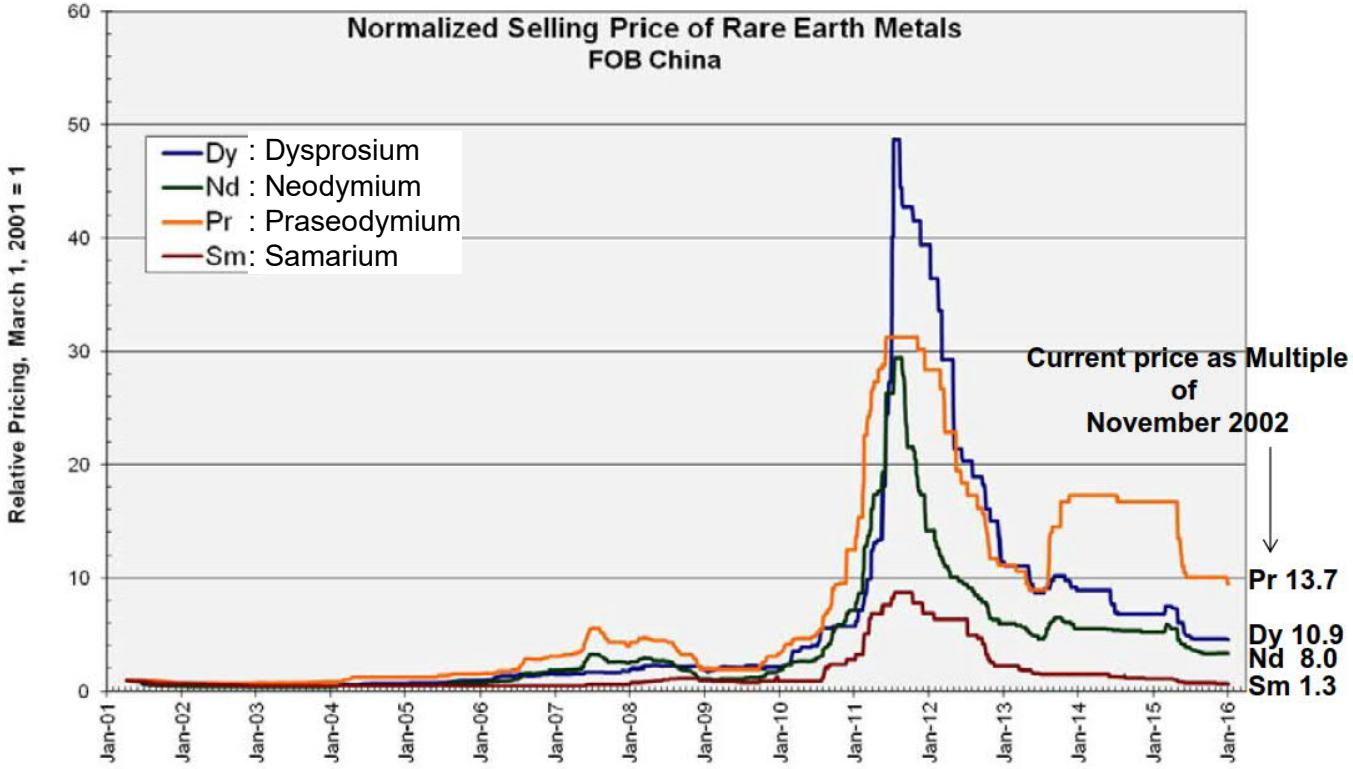




Construction materials

- Soft and hard magnetic materials
- Electric conductors
- Semiconductors
- Insulator materials
- Superconducting materials





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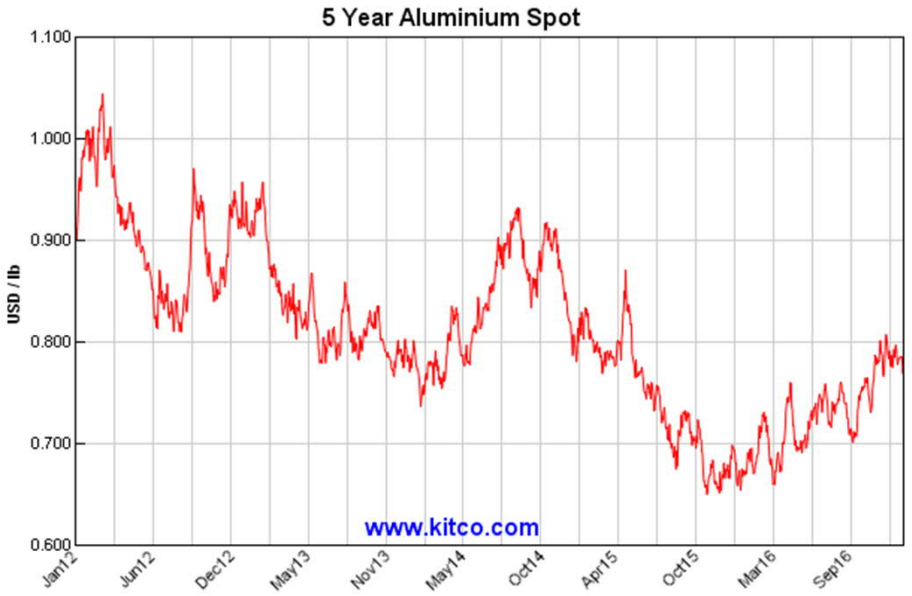

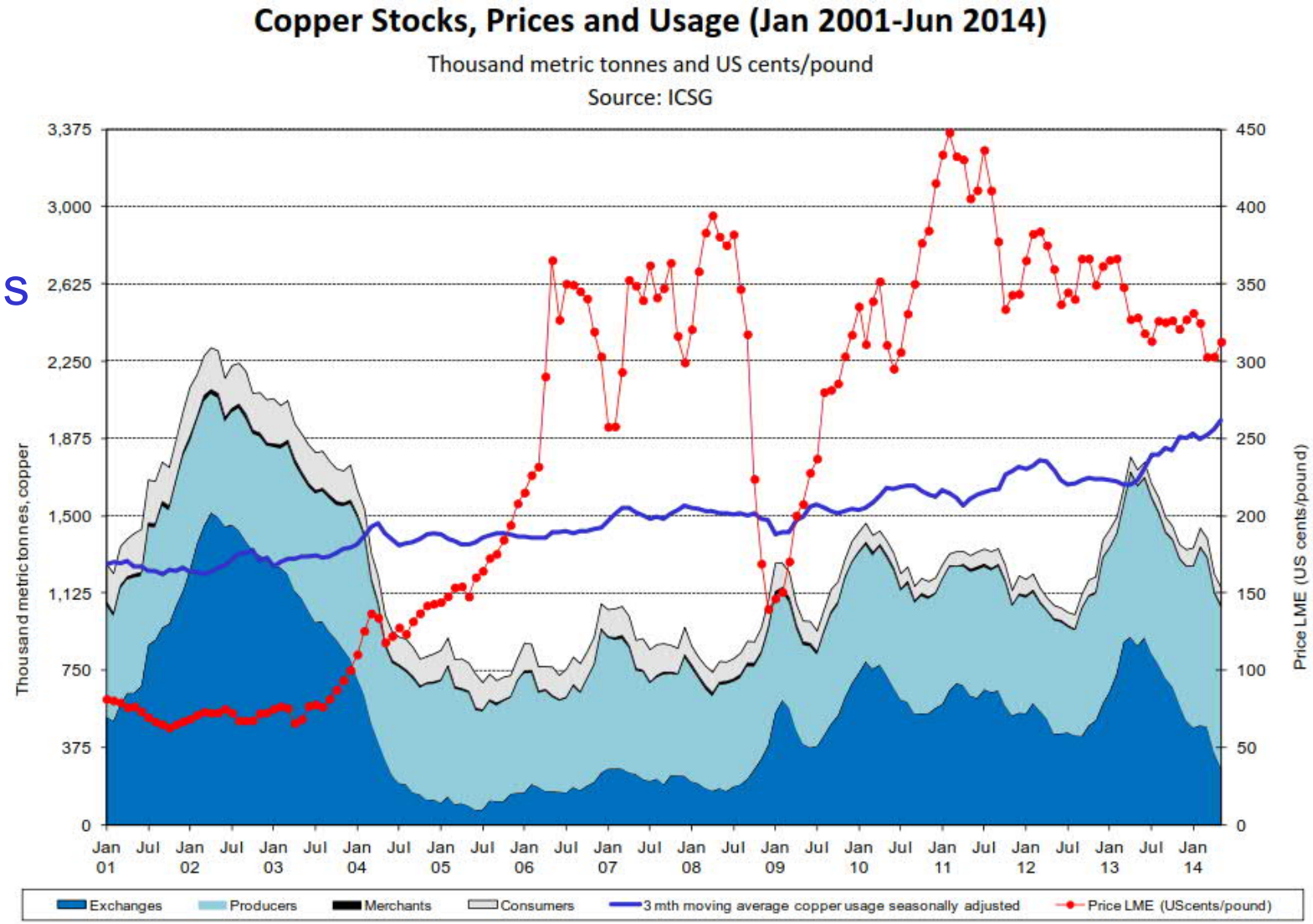

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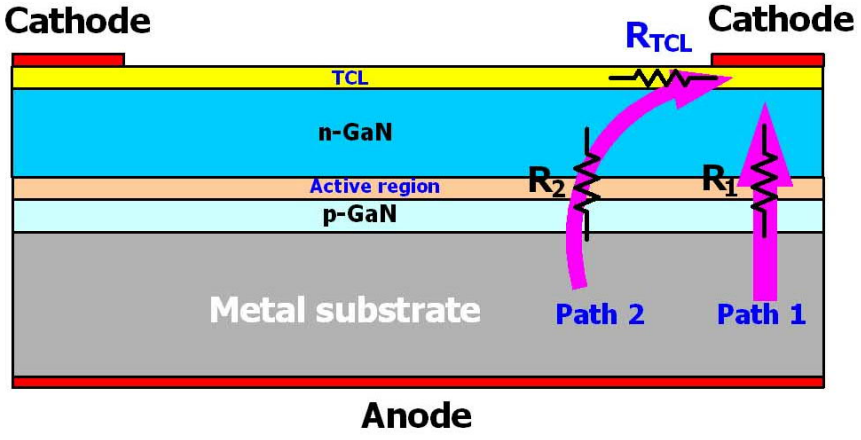

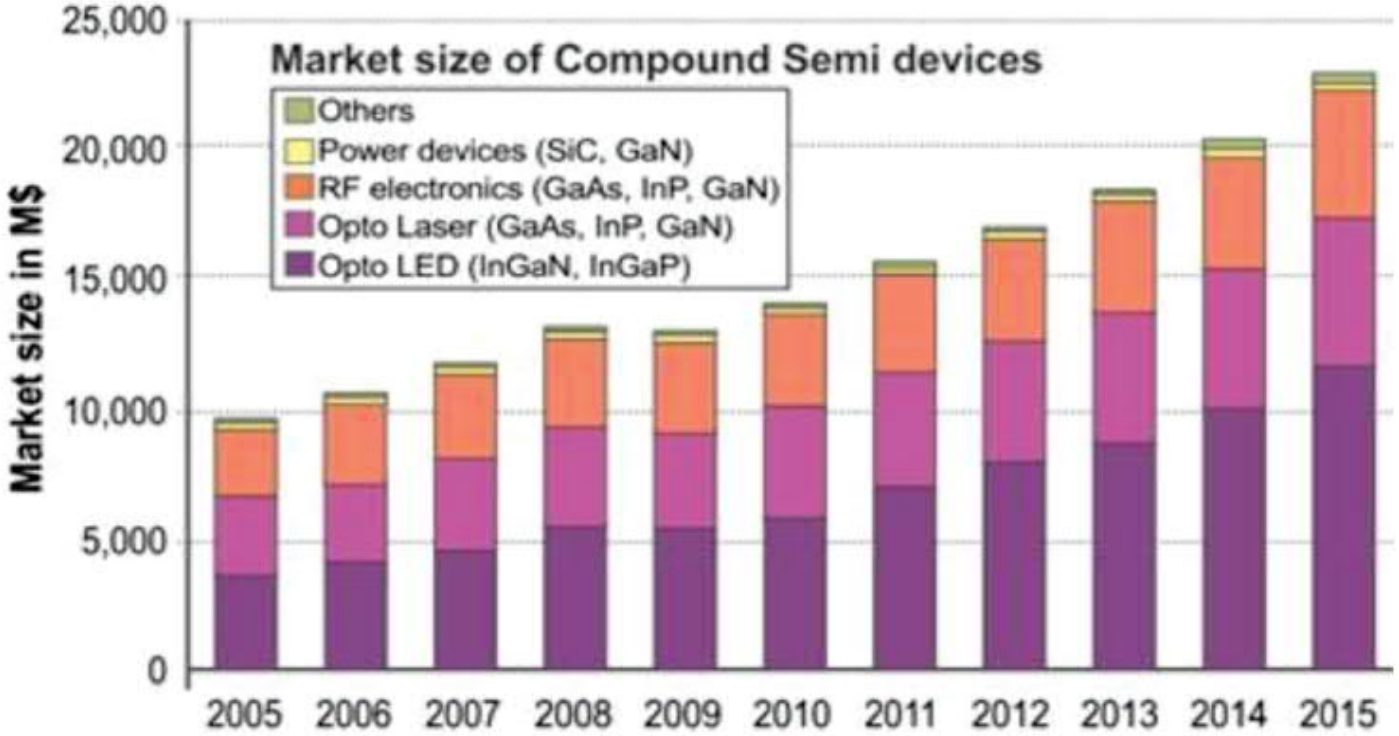

SiC = Silicon Carbide
GaAs = Gallium Arsenide
GaN = Gallium Nitride
InP = Indium Phosphide

http://conf.ncku.edu.tw/research/articles/c/20071116/images/071113071626E8UA3n.jpg

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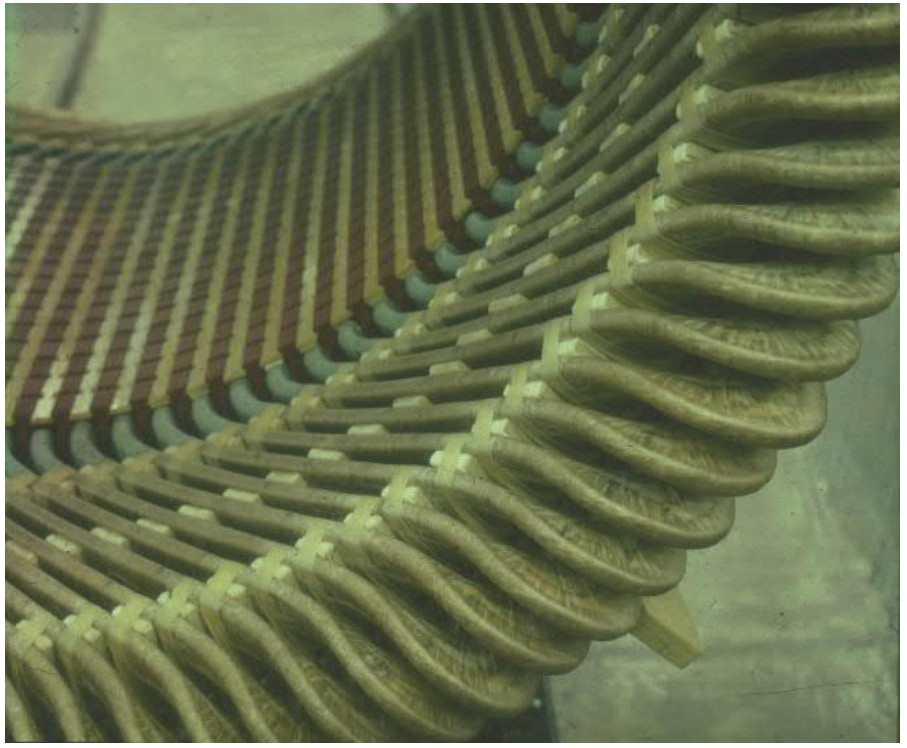

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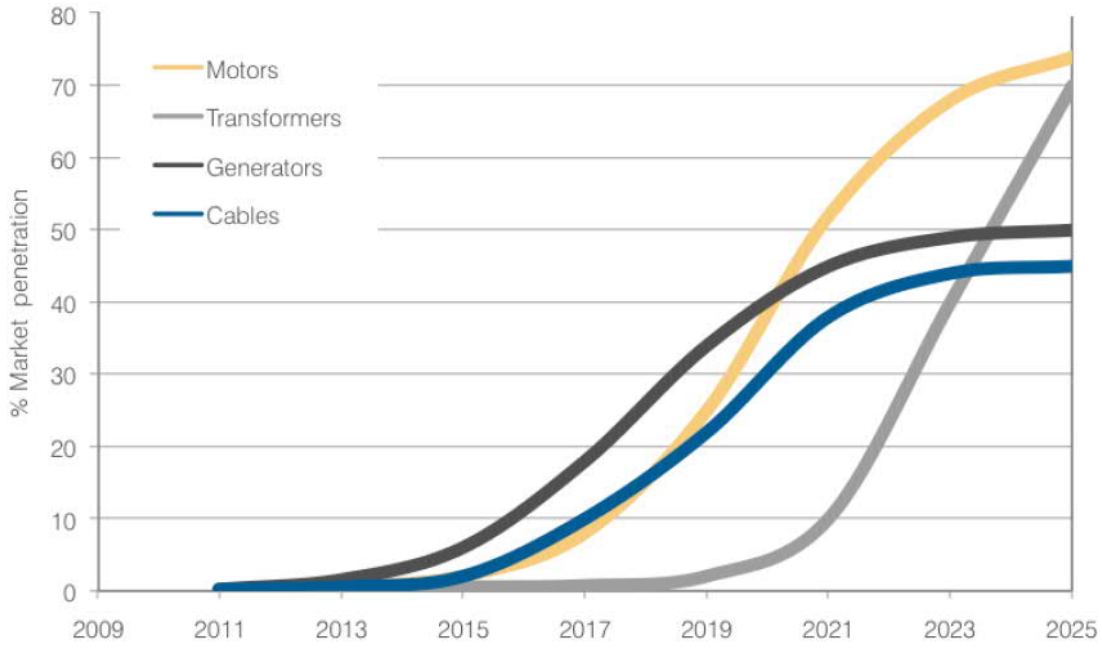

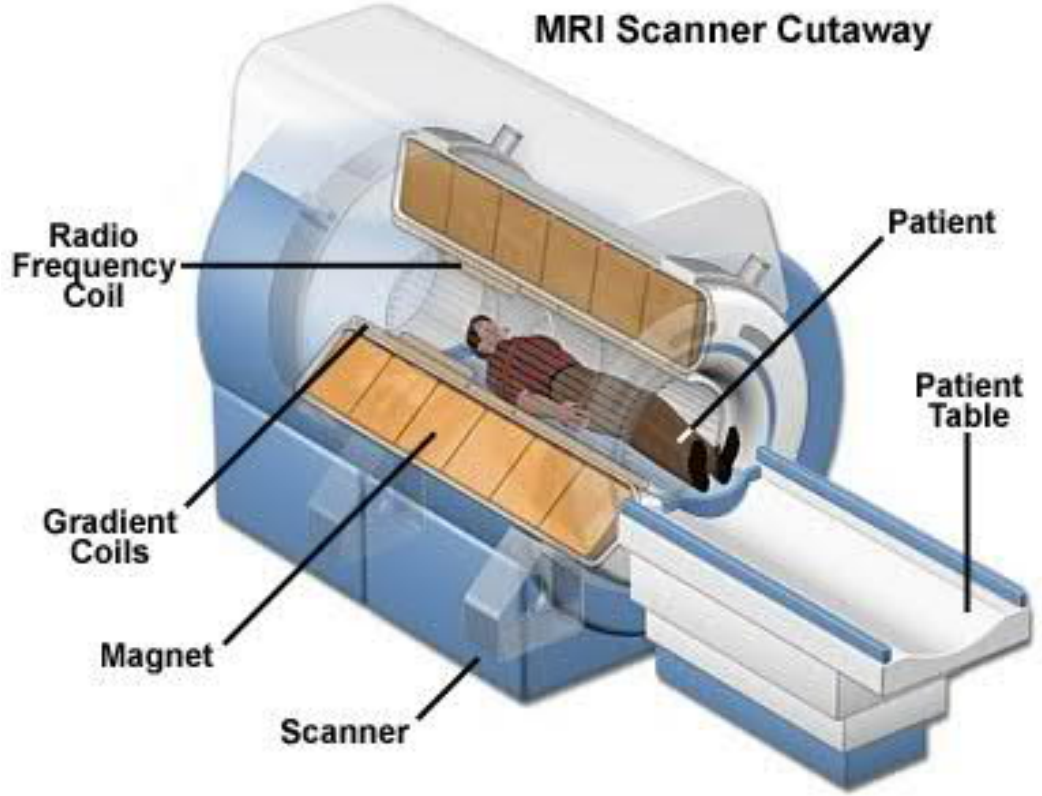

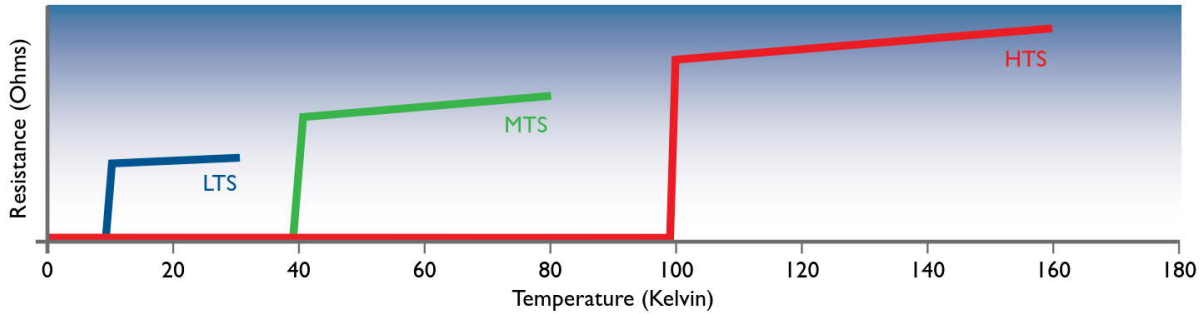

Investigation work 20 min

- Select one or two energy related materials and list the properties that they require from your point of view (5 min)
- Discuss your findings with your mate (5 min)
- Merge your findings and make a list of materials and properties of interest
- Present your list to the class (10 min)
  - You might use internet
  - Evaluate the importance of the materials in your list