

Orientation

메카트로닉스 재료개론 (MFA9008)

창원대학교 신소재공학부

정영웅



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Internal Policy

▣ 지각이란

- 수업 시작보다 10분 초과하여 늦는 경우
- 수업 후 지각한 인원은 면담후 수정.

▣ 결석이란

- 수업 시작에서 30분 초과하여 나타나거나, no-show

▣ 평가

- 출결 (10%)
 - ❖ 지각 (0.5 시간): 1회× 1점 차감
 - ❖ 결석 (1.5 시간): 1회× 3점 차감
- 과제 (20%)
- Mid-term (30%)
- Final (40%)



Internal Policy (continued)

□ 교재

- W. Callister Jr. – 재료과학과 공학
- Materials Science and Engineering: An Introduction

□ 강의 자료

<https://youngung.github.io/teaching/>에서 다운로드

강의 자료는 수시로 업데이트/변경될 수 있습니다 (유의)

□ Interactions

- 강의중
 - ❖ 구두 질문, 혹은 포스트잇
- 강의후
 - ❖ 면담
 - ❖ Email: yjeong@changwon.ac.kr
 - ❖ Office: 52-208



Objectives of today's lecture

- ❑ Understand Materials Classification
- ❑ Understand fundamental 'Material Properties'
- ❑ Understand Material Selection Process

* Metallic materials are primarily discussed

** The structures of investigation may be in various scales (micro, nano, ...)



MSE: an Introduction

- Professor Turner teaches a similar lecture using the same textbook but fully in English.
- This lecture covers a wide range of topics related with Materials Science & Engineering.
- More advanced lectures require the basic understandings on various aspects discussed in this lecture – **I am saying that this lecture is very very important!**



Materials Science and Engineering

□ Engineering (공학이란?)

- The branch of science and technology concerned with the design, building, and use of engines, machines, and structures.

□ Materials Science (재료과학)

- Study the relationships between the structures and properties of materials.
- Structure exist in various scales (nano-, micro-, macro)

□ Materials Engineering (재료공학)

- Design/engineer the structure that meets the set of desired properties.
- Create new products using existing materials / develop technique for processing materials



History of human tied to history of materials



돌, 노끈, 나무



청동: 구리+주석



Cast Iron + 목재

*화순 대곡리 청동기 일괄, 국보 제 143호



Materials for engineered devices/tools

Raw materials in nature



Materials Science?

- New materials?
- Understand what determines a material property
- Develop a way to 'improve' it using the knowledges



Materials for engineered devices/tools

- ❑ Raw materials in nature. Engineered materials
- ❑ Engineering devices / products are usually consisting of various components
 - Cars made of metals, polymers ...
 - Mobile phones?
 - Even hammers?
 - Combinations of various materials (why?)
- ❑ Engineered Materials constitute the world
 - Vehicles, Aircrafts (transportation)
 - Mobile devices (communication)
 - Bridges/Buildings (Infrastructure)



Raise your mobile device and tell me what materials you see

- Ceramics
- Metals
- Polymers
- Composites
- Advanced materials
 - Semiconductor
 - Biomaterials
 - Smart materials
 - Nano-engineered materials

ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ● ALKALI METAL ● ALKALINE EARTH METAL ● TRANSITION METAL ● GROUP 13 ● GROUP 14 ● GROUP 15 ● GROUP 16 ● HALOGEN ● LANTHANIDE

SCREEN



BATTERY



ELECTRONICS



CASING



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Image from
<http://www.compoundchem.com/2014/02/19/the-chemical-elements-of-a-smartphone/>



Elements

Explore the chemical elements through this periodic table

| Group | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
|--------|----------------------|----------------------|--------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------|--------------------|--------------------|
| Period | 1 H 1.008 | | 3 Li 6.94 | 4 Be 9.0122 | | | | | | | | | 5 B 10.81 | 6 C 12.011 | 7 N 14.007 | 8 O 15.999 | 9 F 18.998 | 10 Ne 20.180 | |
| | | | 11 Na 22.990 | 12 Mg 24.305 | | | | | | | | | 13 Al 26.982 | 14 Si 28.085 | 15 P 30.974 | 16 S 32.06 | 17 Cl 35.45 | 18 Ar 39.948 | |
| 4 | 19 K 39.098 | 20 Ca 40.078 | 21 Sc 44.956 | 22 Ti 47.867 | 23 V 50.942 | 24 Cr 51.996 | 25 Mn 54.938 | 26 Fe 55.845 | 27 Co 58.933 | 28 Ni 58.693 | 29 Cu 63.546 | 30 Zn 65.38 | 31 Ga 69.723 | 32 Ge 72.63 | 33 As 74.922 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.798 | |
| 5 | 37 Rb 85.468 | 38 Sr 87.62 | 39 Y 88.906 | 40 Zr 91.224 | 41 Nb 92.906 | 42 Mo 95.96 | [97.91] | 43 Tc 101.07 | 44 Ru 102.91 | 45 Rh 106.42 | 46 Pd 107.87 | 47 Ag 112.41 | 48 Cd 114.82 | 49 In 118.71 | 50 Sn 121.76 | 51 Sb 127.60 | 52 Te 126.90 | 53 I 131.29 | |
| 6 | 55 Cs 132.91 | 56 Ba 137.33 | * | 71 Lu 174.97 | 72 Hf 178.49 | 73 Ta 180.95 | 74 W 183.84 | 75 Re 186.21 | 76 Os 190.23 | 77 Ir 192.22 | 78 Pt 195.08 | 79 Au 196.97 | 80 Hg 200.59 | 81 Tl 204.38 | 82 Pb 207.2 | 83 Bi 208.98 | [208.98] | [209.99] | [222.02] |
| 7 | 87 Fr [223.02] | 88 Ra [226.03] | ** | 103 Lr [262.11] | 104 Rf [265.12] | 105 Db [268.13] | 106 Sg [271.13] | 107 Bh [270] | 108 Hs [277.15] | 109 Mt [276.15] | 110 Ds [281.16] | 111 Rg [280.16] | 112 Cn [285.17] | 113 Nh [284.18] | 114 Fl [289.19] | 115 Mc [288.19] | 116 Lv [293] | 117 Ts [294] | 118 Og [294] |

| | | | | | | | | | | | | | | | |
|--------------|----|----------------------|--------------------|--------------------|--------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|
| *Lanthanoids | * | 57 La 136.91 | 58 Ce 140.12 | 59 Pr 140.91 | 60 Nd 144.24 | 61 Pm [144.91] | 62 Sm 150.36 | 63 Eu 151.96 | 64 Gd 157.25 | 65 Tb 158.93 | 66 Dy 162.50 | 67 Ho 164.93 | 68 Er 167.26 | 69 Tm 168.93 | 70 Yb 173.05 |
| **Actinoids | ** | 89 Ac [227.03] | 90 Th 232.04 | 91 Pa 231.04 | 92 U 238.03 | 93 Np [237.05] | 94 Pu [244.08] | 95 Am [243.06] | 96 Cm [247.07] | 97 Bk [247.07] | 98 Cf [251.08] | 99 Es [252.08] | 100 Fm [257.10] | 101 Md [258.10] | 102 No [259.10] |



Cases of material failures



How to prevent material Failure?

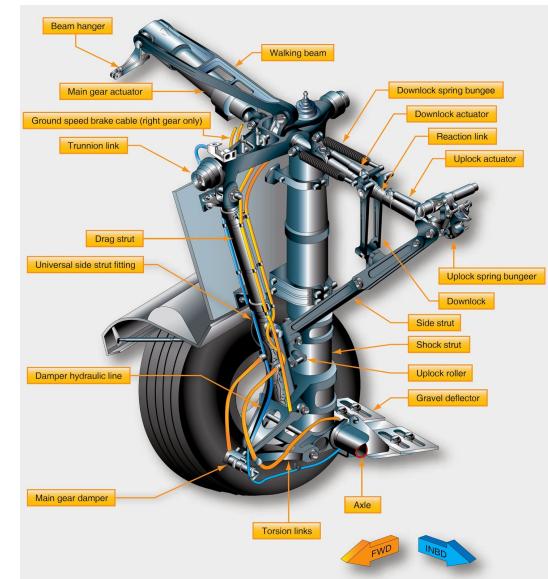


Example 1: Landing gear

Materials used for aircrafts usually are lightweight metals (several types of aluminum alloys are most widely adapted).

However, a large portion of a landing gear is made of steel alloys. By the way, steel alloys are a lot heavier than aluminum.

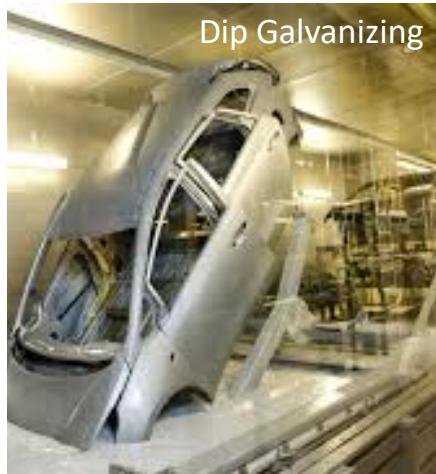
Then, why do the aircraft manufacturers decide to use 'steel' rather than aluminum?



Example 2: Housing for mobile devices



Example 3: Car-body?



Example 4: beverage container



The role of container? (Questions)

Advantages and Disadvantages? (Questions)



Materials “Science” and Materials “Engineering”

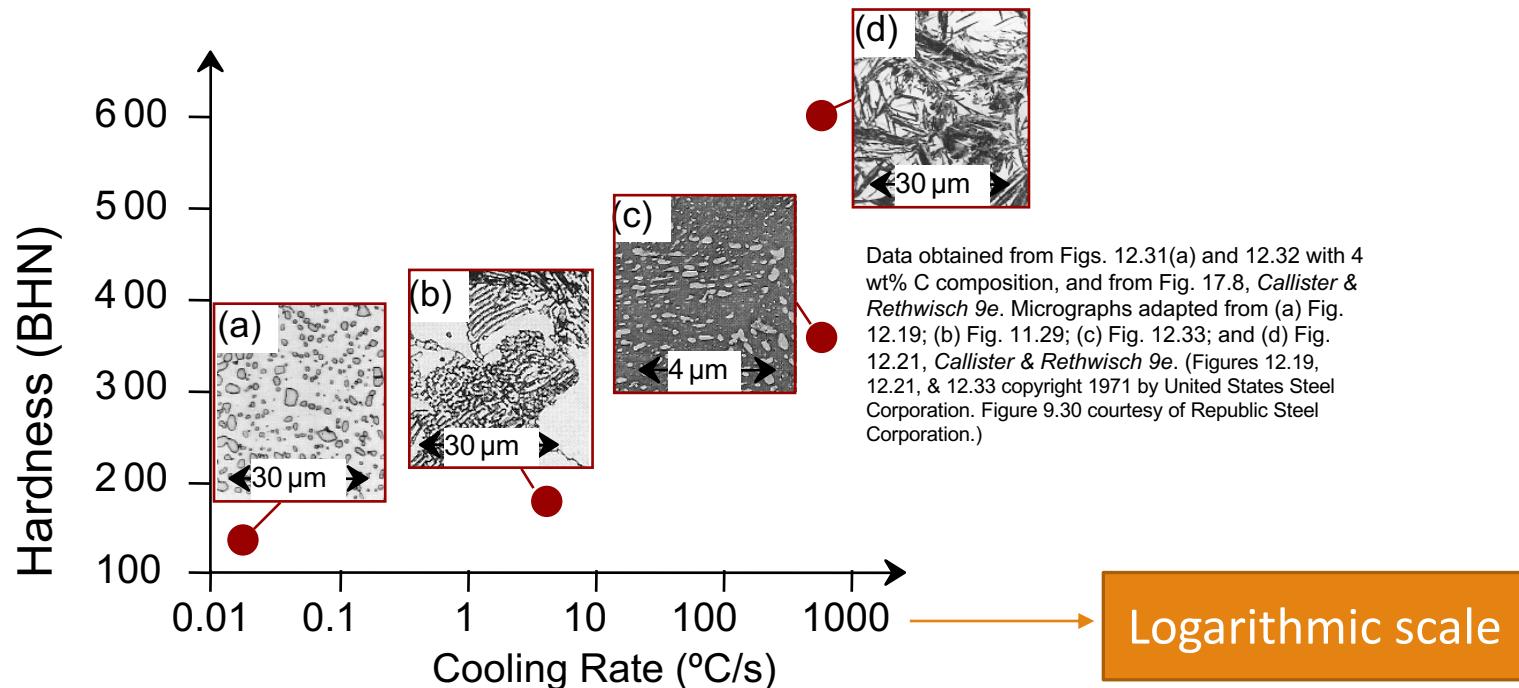


Figure 1.1 The four components of the discipline of materials science and engineering and their interrelationship.



Example: Mechanical (microstructure)

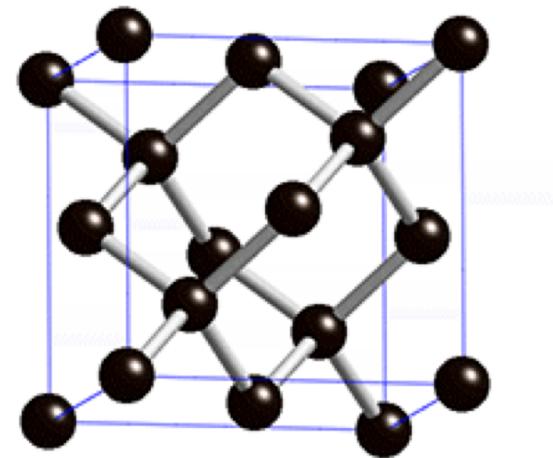
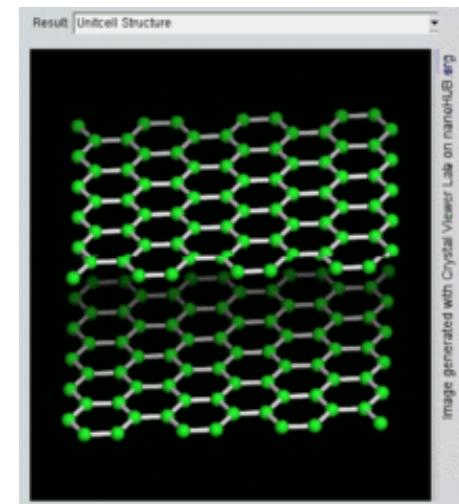
- Properties depend on **structure**
ex: **hardness** vs. (micro) structure of steels



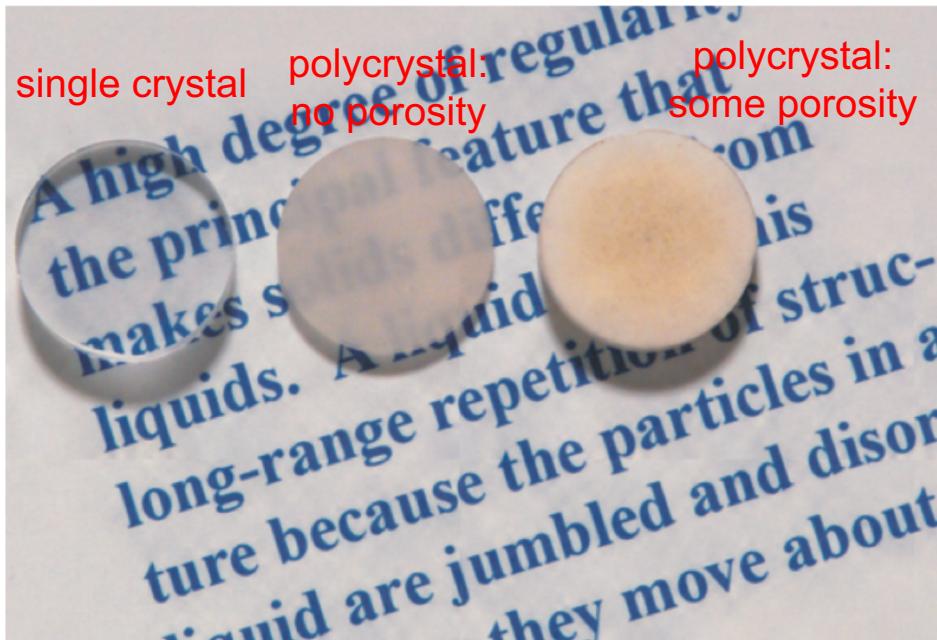
- Processing can change **structure**
ex: structure vs cooling rate of steel



Example: Mechanical (crystal structure)



Examples: Optical



Same crystal structure but different microstructure (porosity)

Aluminum Oxide



Figure 1.1 The four components of the discipline of materials science and engineering and their interrelationship.



Examples: Electrical

- Electrical Resistivity of Copper:

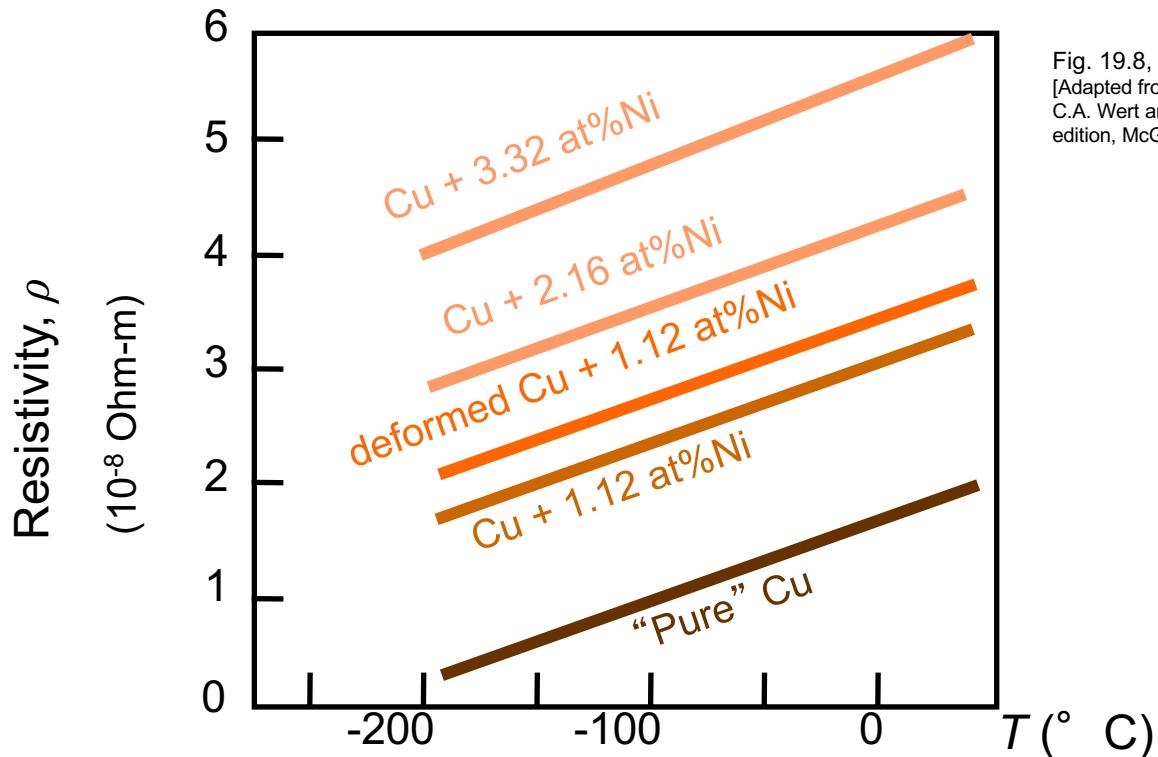


Fig. 19.8, Callister & Rethwisch 9e.
[Adapted from: J.O. Linde, *Ann Physik* 5, 219 (1932); and
C.A. Wert and R.M. Thomson, *Physics of Solids*, 2nd
edition, McGraw-Hill Company, New York, 1970.]

- Adding “**impurity**” atoms to Cu increases **resistivity**.
- Deforming Cu increases **resistivity**.



DETERIORATIVE

- Stress & Saltwater...
-- causes cracks!

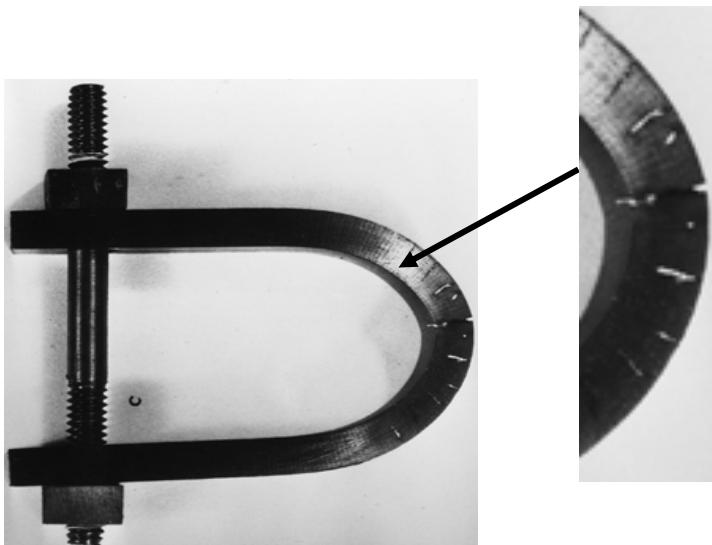
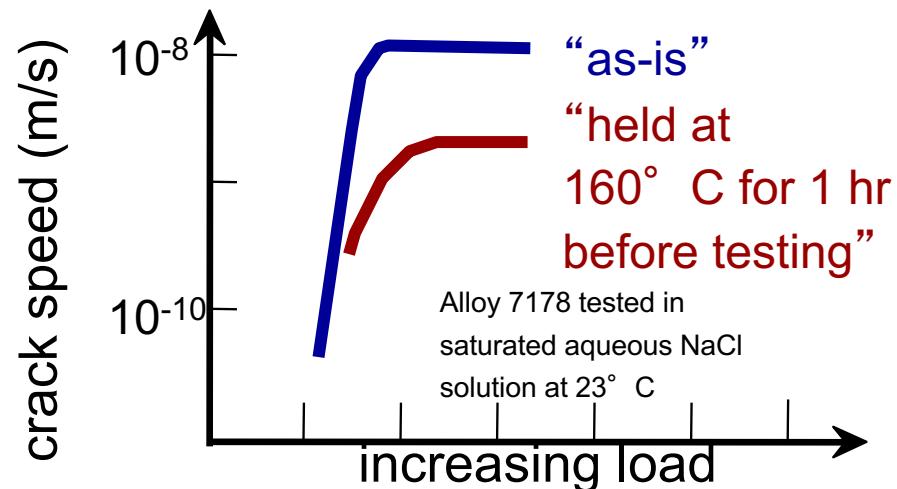


Fig. 18.21, Callister & Rethwisch 9e.
(from *Marine Corrosion, Causes, and Prevention*,
John Wiley and Sons, Inc., 1975.)

- Heat treatment: slows crack speed in salt water!



Adapted from Fig. 11.20(b), R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials" (4th ed.), p. 505, John Wiley and Sons, 1996. (Original source: Markus O. Speidel, Brown Boveri Co.)



What would be your future role?

❑ Imagine that you are a team member working in a mobile phone manufacturing company. Your mission, as a senior material engineer, is to correctly choose materials used in a new mobile phone is targeted to launch in year 2019.

- What factors should be considered?
- Certain performance guidelines?
- You are expected know what materials are available from the material suppliers

❑ Materials Classifications

- Metals
- Ceramics
- Polymers
- New materials?



Types of Materials

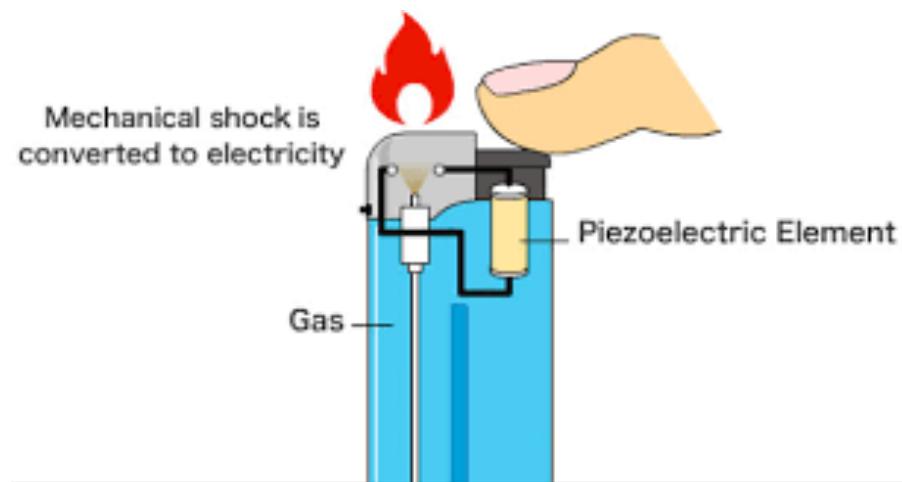
- **Metals:**
 - Strong, ductile
 - High thermal & electrical conductivity
 - Opaque, reflective.
- **Polymers/plastics:** Covalent bonding → sharing of electrons
 - Soft, ductile, low strength, low density
 - Thermal & electrical insulators
 - Optically translucent or transparent.
- **Ceramics:** ionic bonding (refractory) – compounds of metallic & non-metallic elements (oxides, carbides, nitrides, sulfides)
 - Brittle, glassy, elastic
 - Non-conducting (insulators)



What is a material property?

- Strength?
 - Density?
 - Electric/thermal conductivity
 - This also gives a way to measure the specific material property
-
- Example: 밀도와 무게의 차이

Stimuli and response



What properties matter?

- Mechanical
- Electro-magnetism
- Chemical



Reading Assignment

- ❑ Chapter 1 of the text book.

