Orientation

메카트로닉스 재료개론 (MFA9008)

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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): 1회x 1점 차감
    - 결석 (1.5 시간): 1회x 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
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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 …
  - Mobiles 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

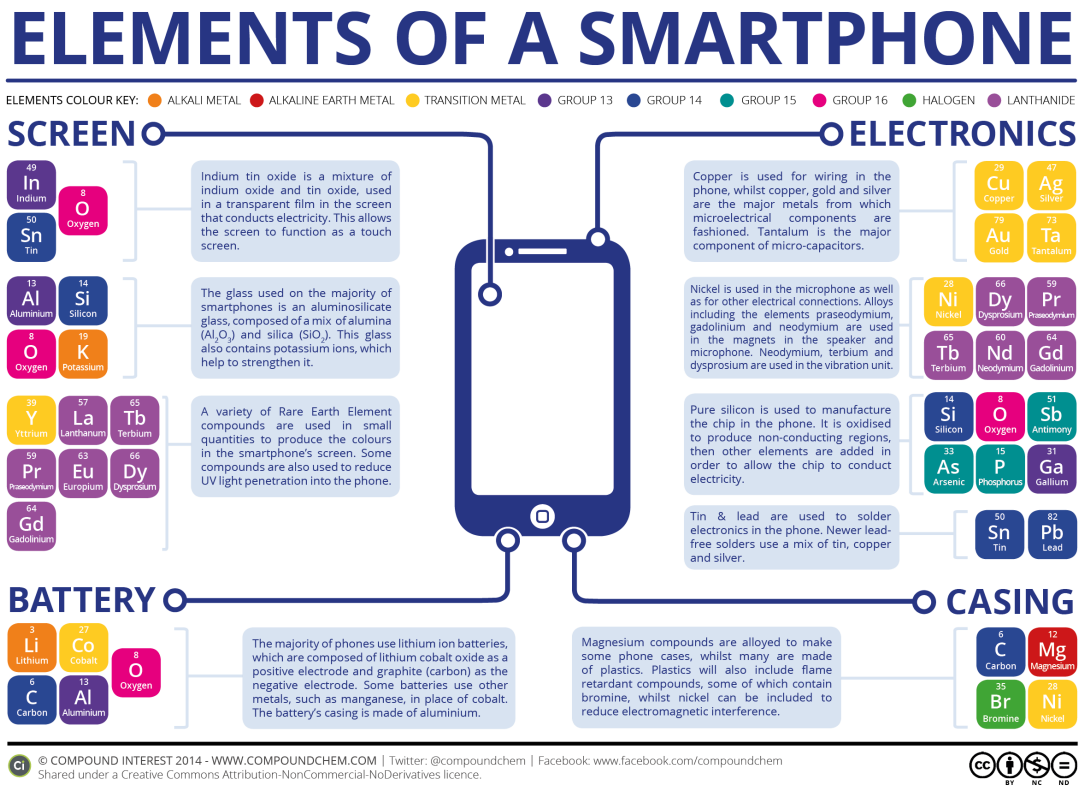


Image from
http://www.compoundchem.com/2014/02/19/the-chemical-elements-of-a-smartphone/

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	1 H 1.008																		2 He 4.0026
2	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
3	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	43 Tc [97.91]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 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	84 Po [208.98]	85 At [209.99]	86 Rn [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]

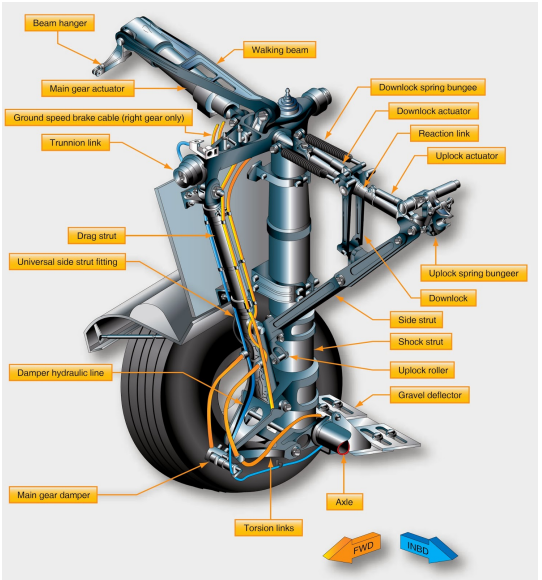
*Lanthanoids	*	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [144.91]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05
**Actinoids	**	89 Ac [227.03]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237.05]	94 Pu [244.06]	95 Am [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 steels. By the way, steels 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”

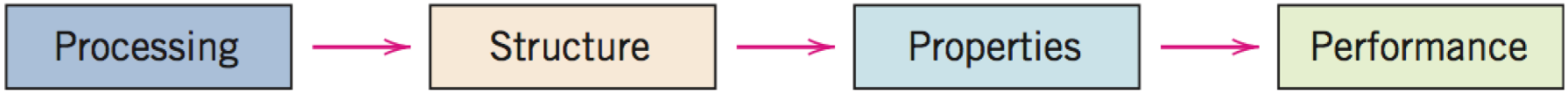
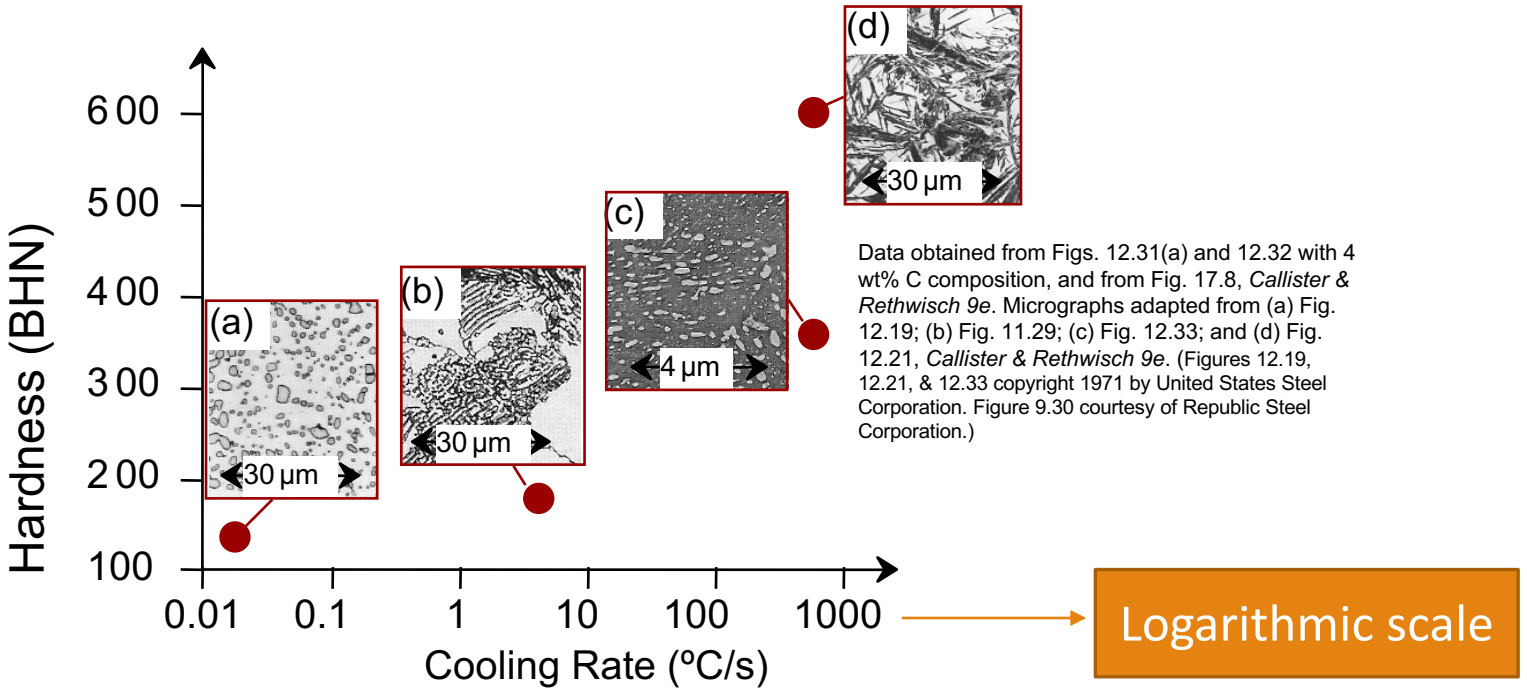


Figure 1.1 The four components of the discipline of materials science and engineering and their interrelationship.

Example: Mechanical (microstructure)

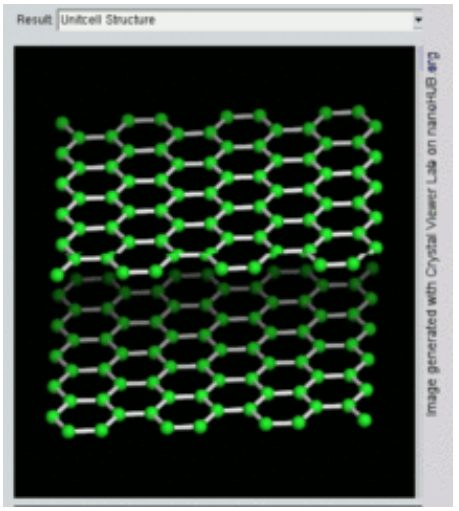
- Properties depend on structure
  ex: hardness vs. (micro) structure of steels

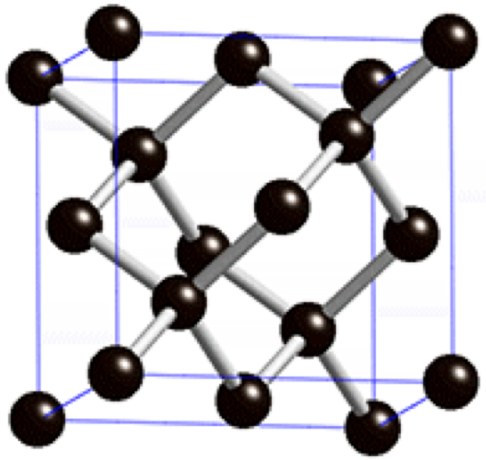


Data obtained from Figs. 12.31(a) and 12.32 with 4 wt% C composition, and from Fig. 17.8, *Callister & Rethwisch 9e*. Micrographs adapted from (a) Fig. 12.19; (b) Fig. 11.29; (c) Fig. 12.33; and (d) Fig. 12.21, *Callister & Rethwisch 9e*. (Figures 12.19, 12.21, & 12.33 copyright 1971 by United States Steel Corporation. Figure 9.30 courtesy of Republic Steel Corporation.)

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

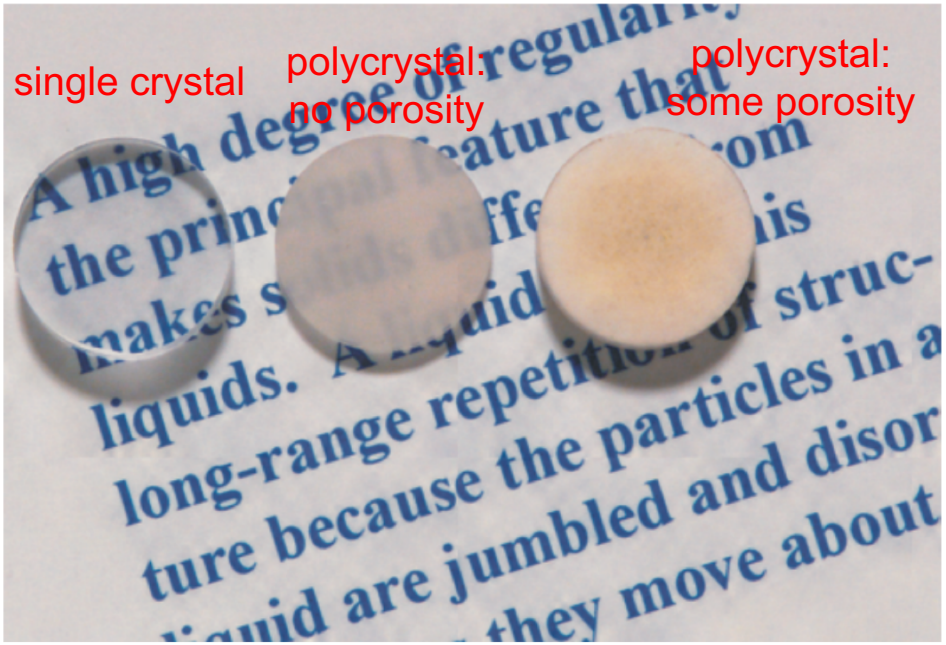
Example: Mechanical (crystal structure)





Images from wikipedia.org

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:

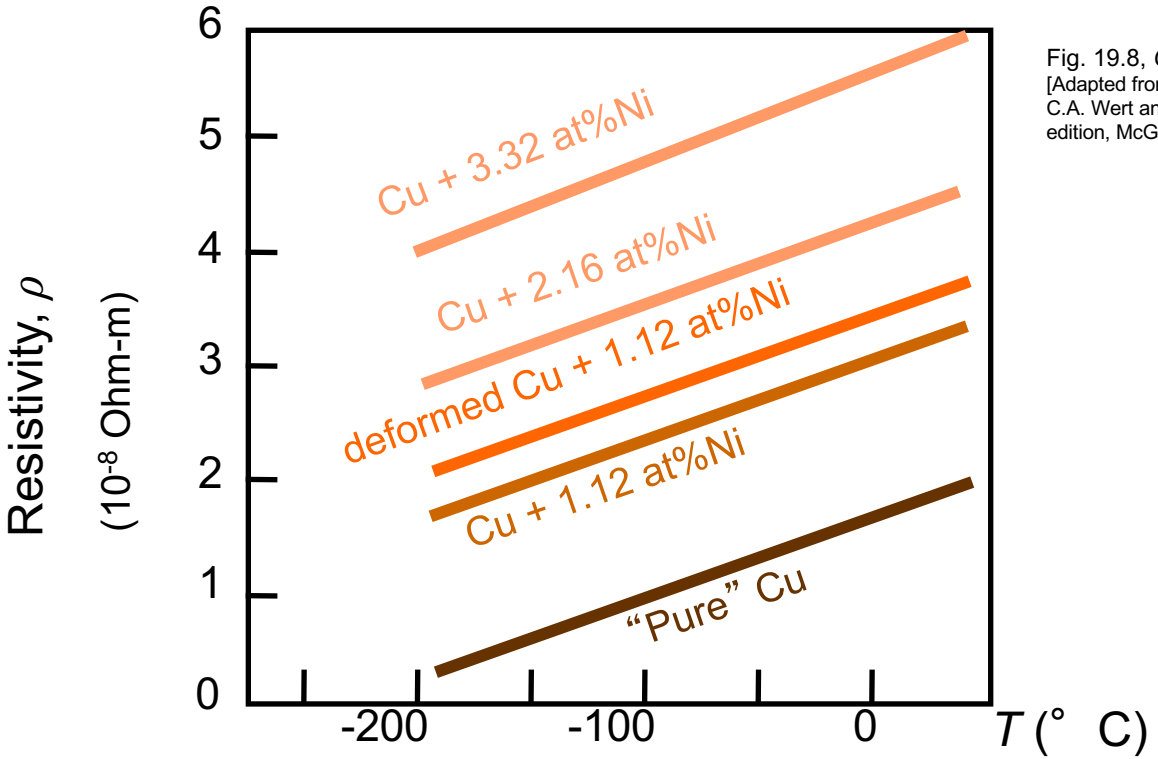


Fig. 19.8, *Callister & Rethwisch 9e.*
[Adapted from: J.O. Linde, *Ann Physik* **5**, 219 (1932); and C.A. Wert and R.M. Thomson, *Physics of Solids*, 2nd edition, McGraw-Hill Company, New York, 1970.]

- Adding "impurity" atoms to Cu increases resistivity.
- Deforming Cu increases resistivity.

DETERIORATIVE

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

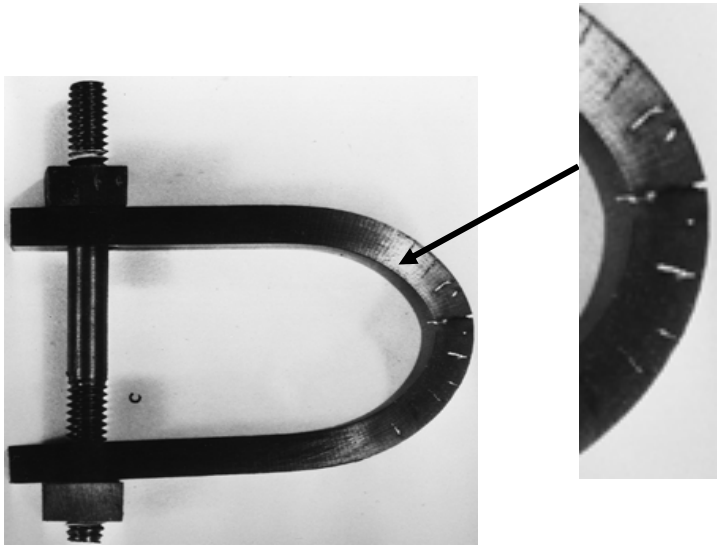
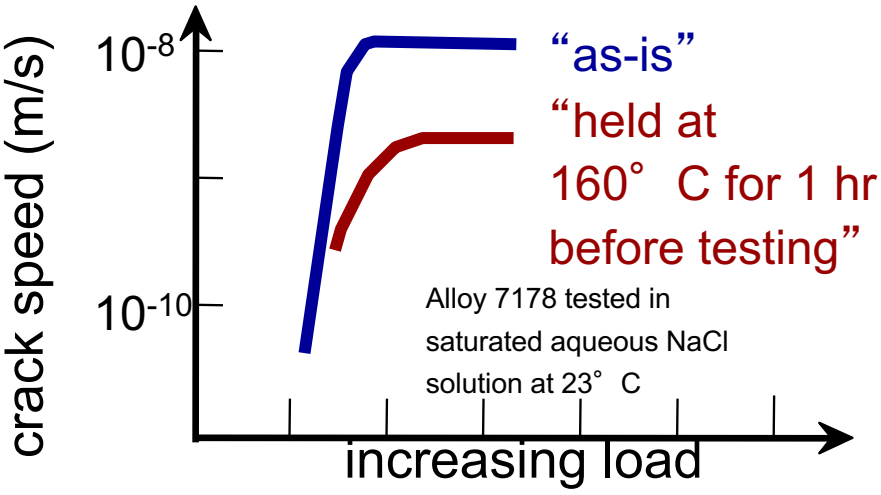


Fig. 18.21, *Callister & Rethwisch 9e.*
(from *Marine Corrosion, Causes, and Prevention*, John Wiley and Sons, Inc., 1975.)

- 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 to be used in a new mobile phone targeted to launch in year 2020.
  - 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

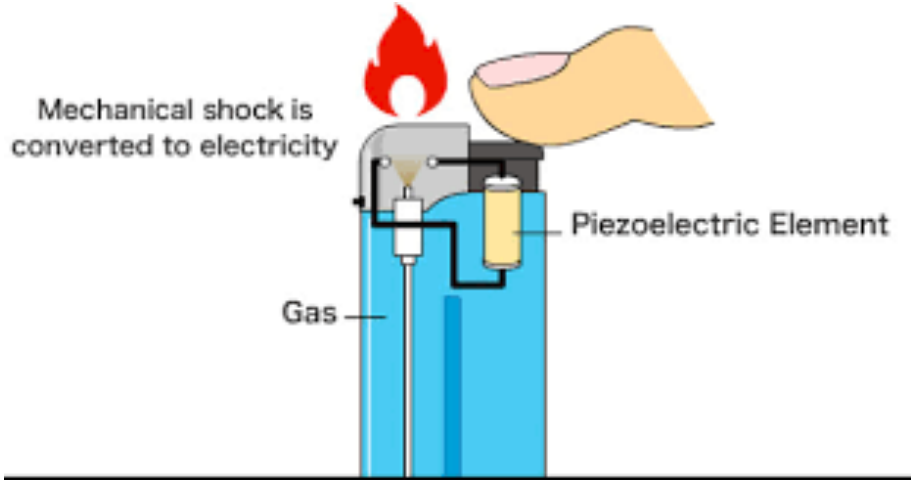
- Metals:
  - Strong, ductile
  - High thermal & electrical conductivity
  - Opaque, reflective.
- Polymers/plastics: Covalent bonding → sharing of electrons
  - Soft, ductile, low strength, low density
  - Thermal & electrical insulators
  - Optically translucent or transparent.
- Ceramics: ionic bonding (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

Stimuli and response

- Example: 밀도와 무게의 차이



What properties matter?

- Mechanical
- Electro-magnetism
- Chemical
- Thermal
- Optical
- …

Reading Assignment

- Chapter 1 of the text book.