Chapter 1
Introduction

Materials Science

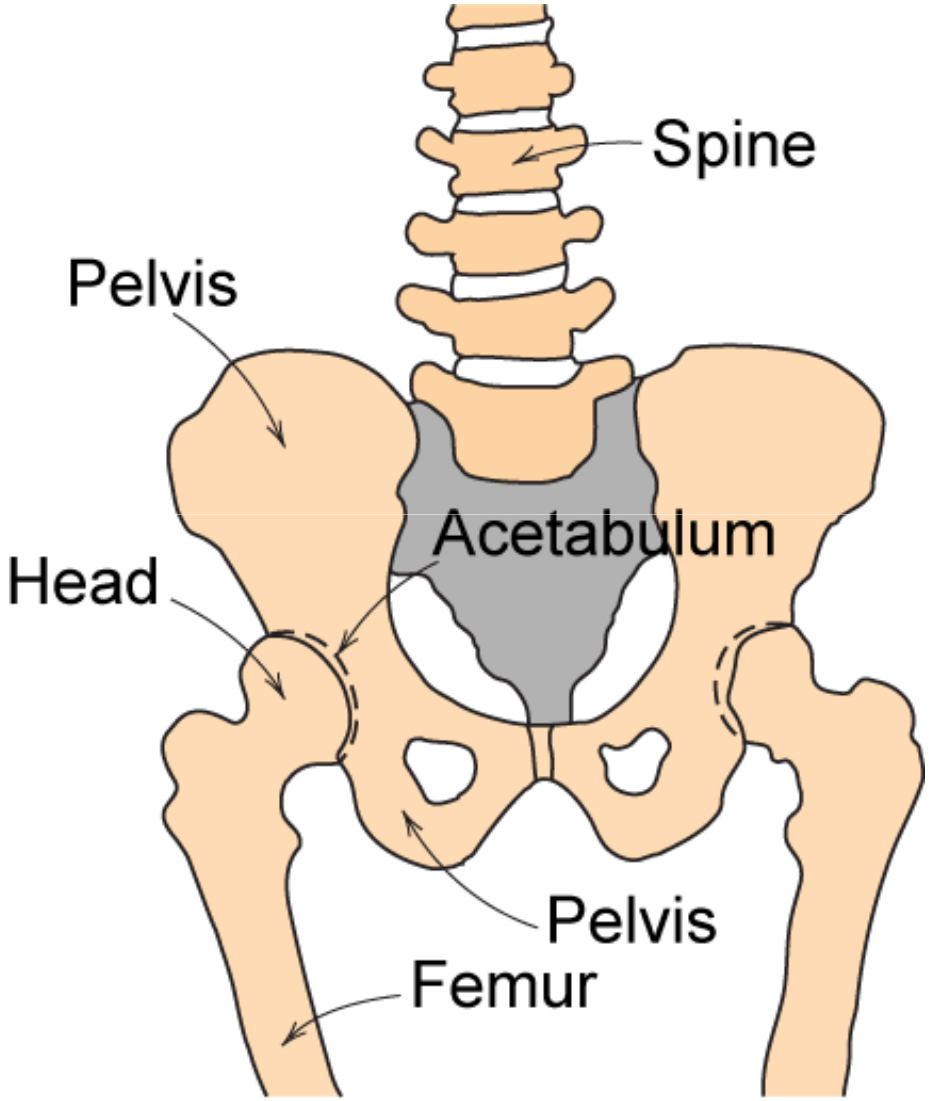
- What is materials science?

  Materials science or materials engineering is an interdisciplinary field involving the properties of matter and its applications to various areas of science and engineering. This science investigates the relationship between the structure of materials at atomic or molecular scales and their macroscopic properties.
- Materials drive our society
  - Stone Age - Bronze Age - Iron Age
  - Now? Silicon Age? Polymer Age?

Example – Hip Implant

With age or certain illnesses joints deteriorate. Particularly those with large loads (such as hip).

- Requirements
  - mechanical strength (many cycles)
  - good lubricity
  - biocompatibility



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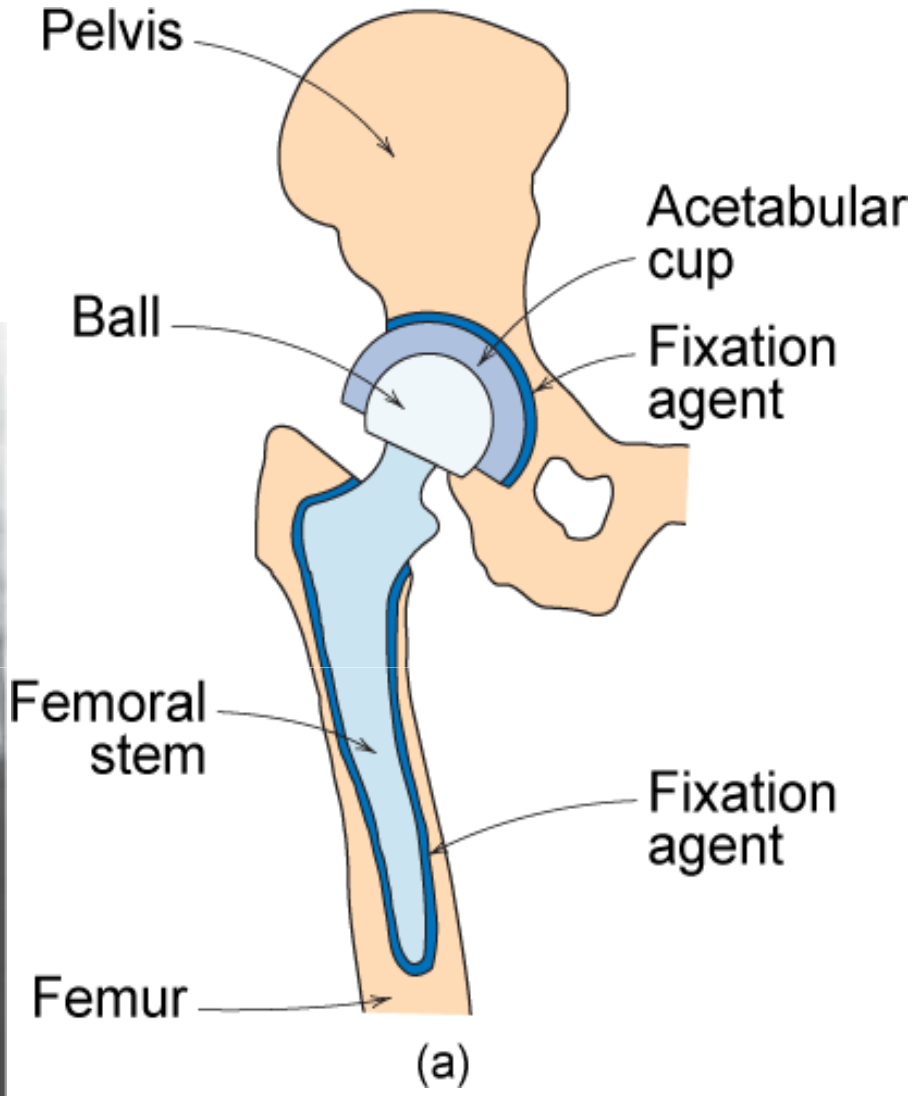
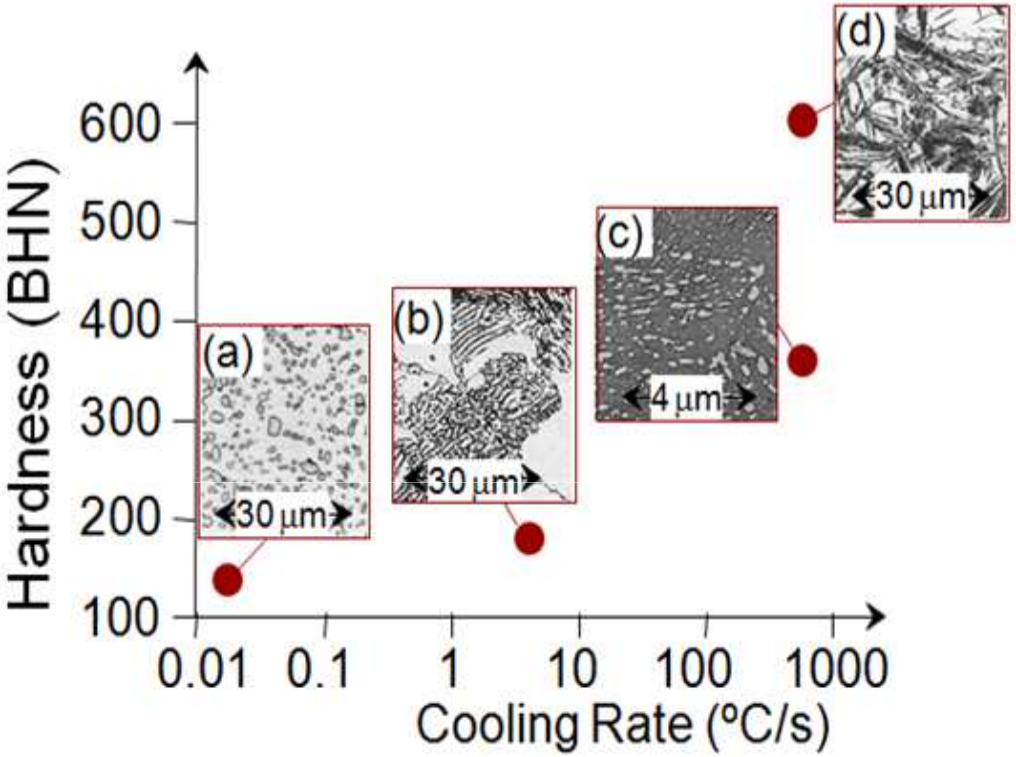


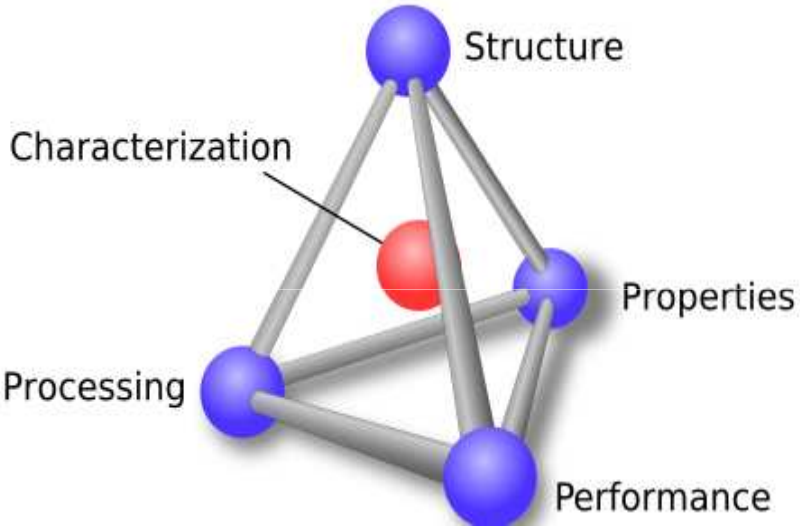
(a)

Dr. Mubarak

- Key problems to overcome
  - fixation agent to hold acetabular cup
  - cup lubrication material
  - femoral stem – fixing agent (“glue”)
  - must avoid any debris in cup

Structure, Processing, & Properties





- Properties depend on structure , ex: hardness vs structure of steel
- Processing can change structure, ex: structure vs cooling rate of steel

Types of Materials

- Metals:
  - Strong, ductile
  - high thermal & electrical conductivity
  - opaque, reflective.
- Polymers/plastics: Covalent bonding
  - 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)

The Materials Selection Process

1- Pick Application ⟹ Determine required Properties.

Properties: mechanical, electrical, thermal, magnetic, optical, deteriorative.

2- Properties ⟹ Identify candidates Material(s)

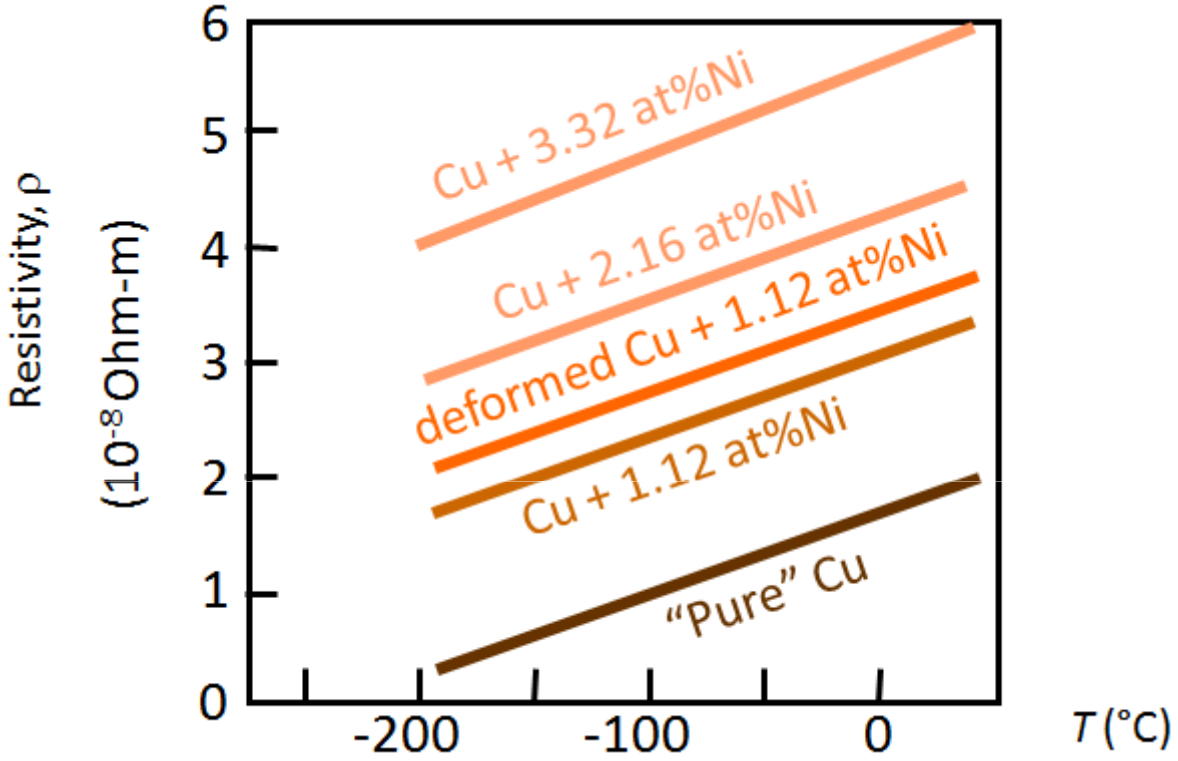
Material: structure, composition

3- Material ⟹ Identify required Processing

Processing: changes structure and overall shape

Ex: casting, sintering, vapor deposition, doping, forming, joining, annealing

ELECTRICAL



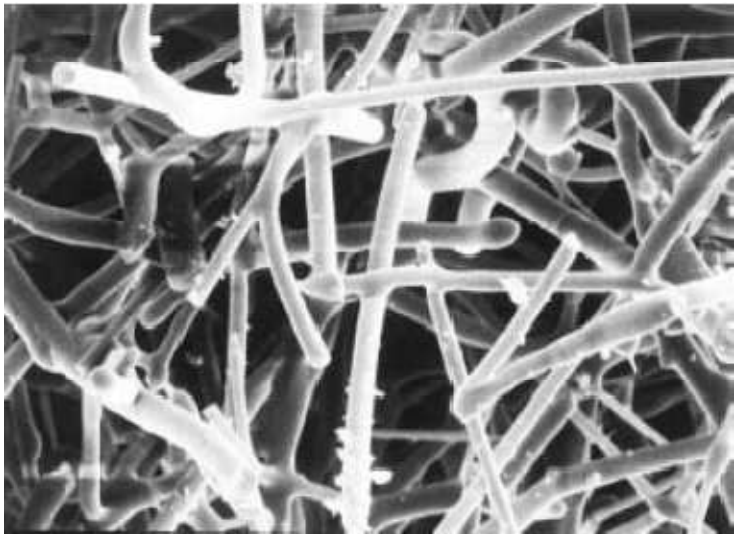
Electrical Resistivity of Copper:

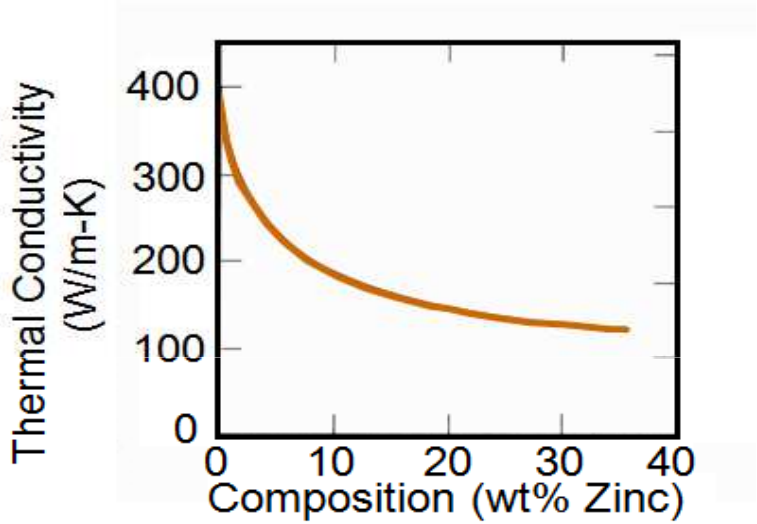
- Adding "impurity" atoms to Cu increases resistivity.
- Deforming Cu increases resistivity.

THERMAL

Shuttle Tiles:

- Silica fiber insulation offers low heat conduction.





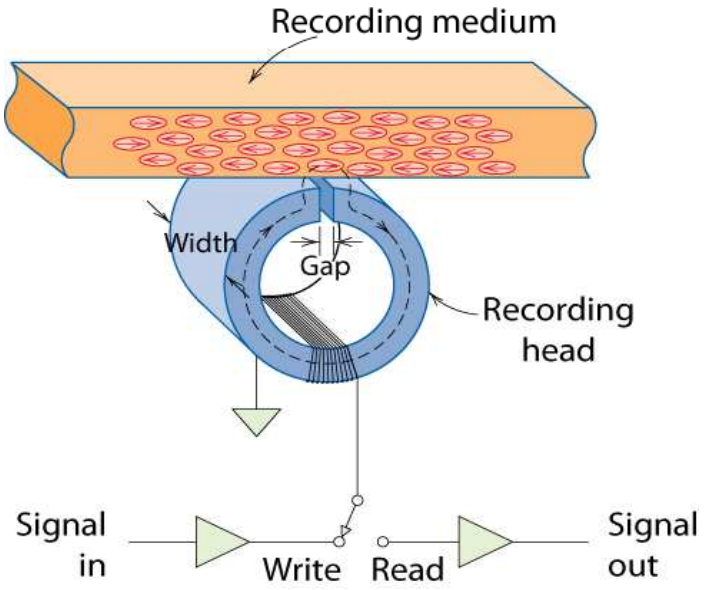
Thermal Conductivity of Copper:

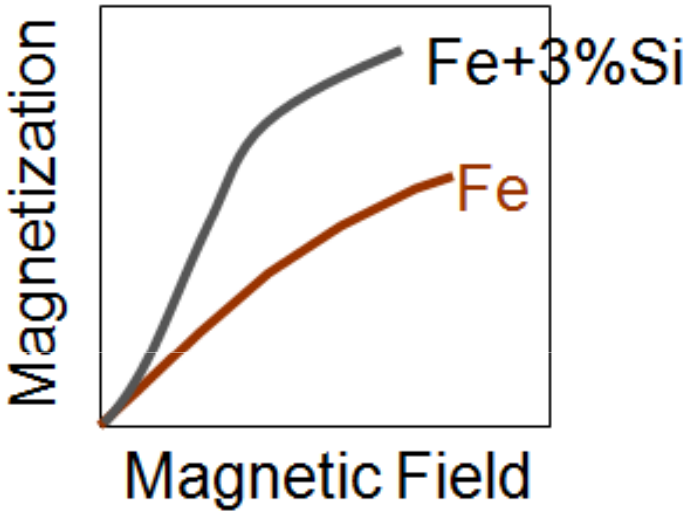
• It decreases when you add zinc.

MAGNETIC

Magnetic Storage:

- Recording medium is magnetized by recording head.



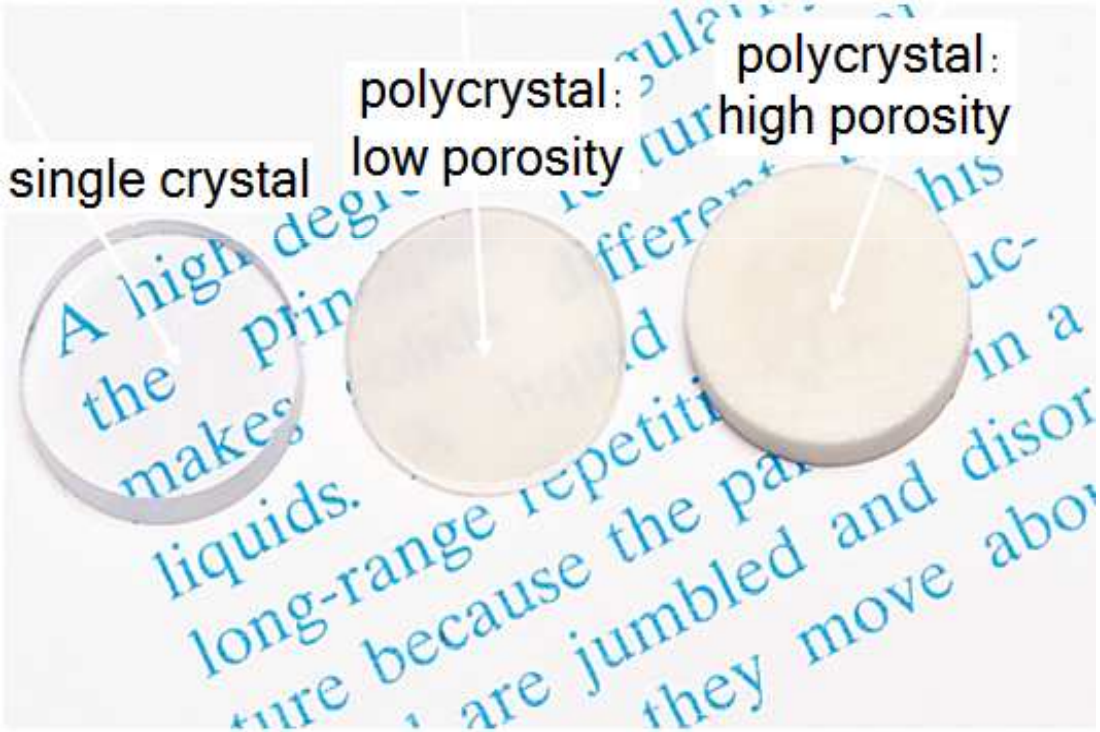


Magnetic Permeability

Adding 3 % Si makes Fe a better recording medium

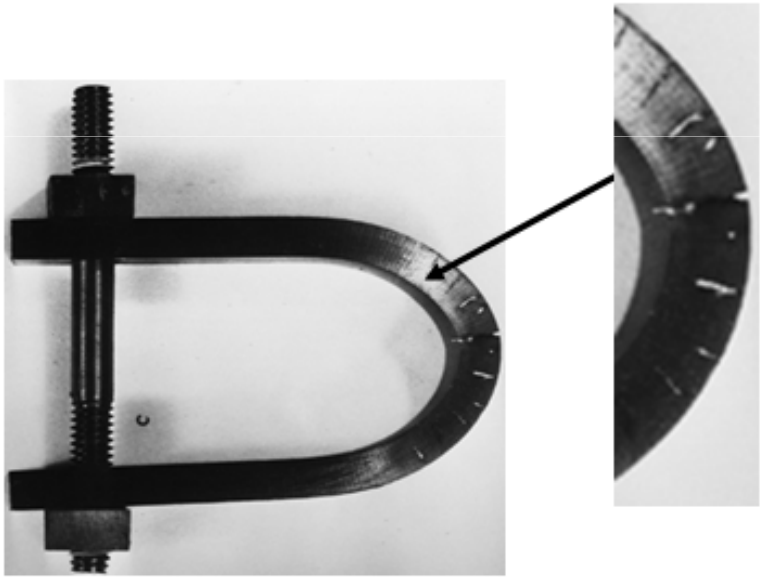
OPTICAL

- Transmittance: Aluminum oxide may be transparent, translucent, or opaque depending on the material structure.



DETERIORATIVE

Stress & Saltwater:
causes cracks



Heat treatment:
slows crack speed in salt water!