



Dental materials

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Lecture 7

Titanium alloys

Introduction- Titanium and its alloys

- **Titanium** is named after the **Titans**, the powerful sons of the earth in Greek mythology.
- Titanium is the **forth abundant metal** on earth crust (~ 0.86%) after aluminium, iron and magnesium.
- Not found in its free, pure metal form in nature but as **oxides**, i.e., ilmenite (**FeTiO_3**) and rutile (**TiO_2**).
- Found only in small amount in Thailand.
- Have similar **strength as steel** but with a **weight nearly half of steel**.



Titans



Ilmenite (FeTiO_3)



Rutile (TiO_2)



Suranaree University of Technology

Tapany Udomphol mineral.galleries.com

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- Titanium in its pure form is a silvery metal known for its strength and low density compared to other similarly hard metals. In most industries, however, titanium alloy is much more commonly used.
- Because of its physical and chemical properties, the metal has become useful in a wide variety of industries and applications such as medical equipment, chemical plants, military installations, and sports gear.

Classification of titanium alloys

- **Commercially pure (CP) titanium alpha and near alpha titanium alloys**

- Generally non-heat treatable and weldable
- Medium strength, good creep strength, good corrosion resistance

- **Alpha-beta titanium alloys**

- Heat treatable, good forming properties
- Medium to high strength, good creep strength

- **Beta titanium alloys**

- Heat treatable and readily formable
- Very high strength, low ductility

Different crystal structures and properties → allow manipulation of heat treatments to produce different types of alloy microstructures to suit the required mechanical properties.



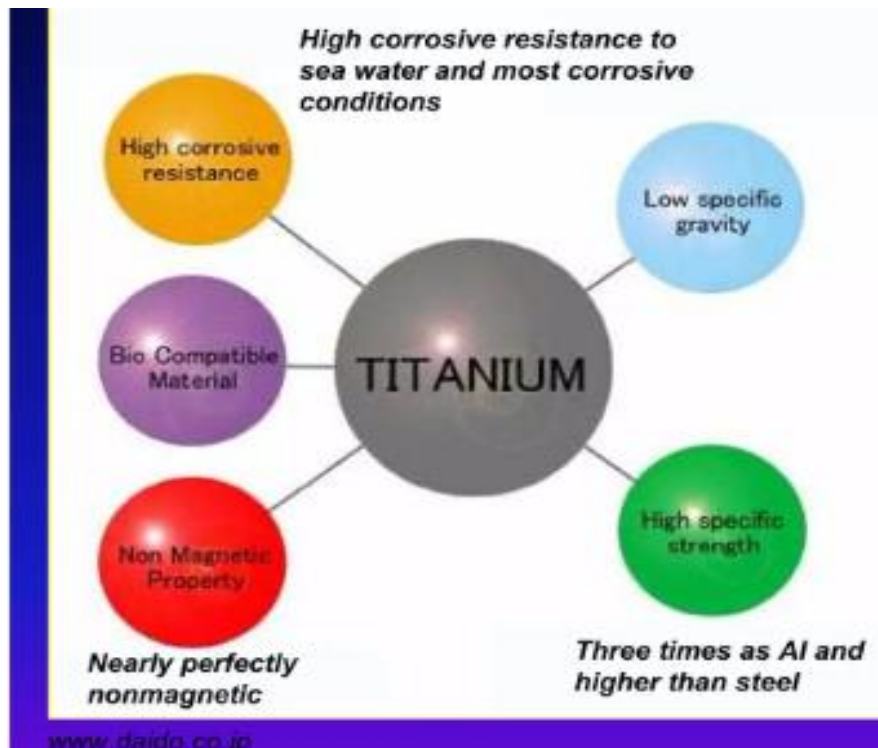
Ti in dentistry

- The most widely used titanium alloy in dentistry and for general engineering applications is Ti-6Al-4V, which is an **α - β alloy**.
- Although this alloy has greater strength than CP Ti, it is not as attractive for dentistry and biomedical applications because of some concerns about health hazards from the slow release of aluminum and vanadium.

BIOMEDICAL APPLICATION:

- Titanium alloys have been extensively used for the manufacturing of metal orthopedic joint replacements and bone plate surgeries. They are normally produced from wrought or cast bar stock by CNC, CAD-driven machining, or powder metallurgy.
- Among all titanium and its alloys, the mainly used materials in biomedical field are the commercially pure titanium (cp Ti, grade 2) and Ti-6Al-4V (grade 5) alloy. They are widely used as **hard tissue replacements in artificial bones, joints and dental implants**.

Advantages of titanium alloy



General application of titanium

AEROSPACE	MEDICAL
•Civil •Military •Space	•Orthopaedic Implants •Bone Screws •Trauma Plates •Dental Fixtures •Surgical Instruments
INDUSTRIAL	SPECIALIST
•Petrochemical •Offshore •Subsea •Metal Finishing •Pulp & Paper •General Engineering	•Body Jewellery •Ultrasonic Welding •Motor Racing Components •Marine •Bicycle •Sports Equipment

Wrought Alloys

- **Wrought:** Beaten to shape.
- **Alloys:** A metal made by combining two or more metallic elements to give greater strength or resistance to corrosion

- What are wrought metal alloys?



PARTIAL DENTURE CLASP



ENDODONTIC FILES



SURGICAL INSTRUMENTS



Heat
treatment

Wrought
alloy

Stainless steel

Orthowires, paed
crowns, Endo
instts, surgical instt, clasps

Nickle Titanium

(Ni ti)

Ortho wires
Endo instruments

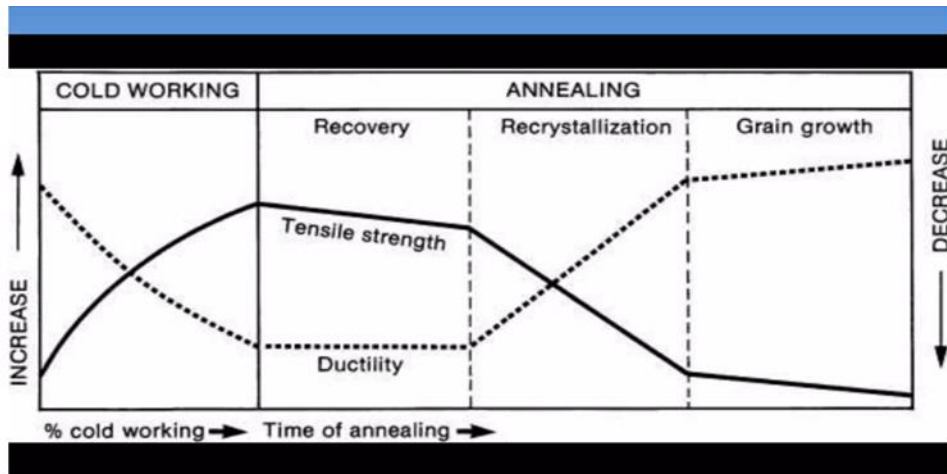
Cobalt Chromium

Beta Titanium

Wrought commercially pure Titanium

ORTHODONTIC
BRACKETS

Manipulations



COLD WORKING

- Process in which a metal is hammered, drawn or bent into shapes at temperature well below the crystallization temperature of metal (often at room temperature)
- Cold working increase hardness, strength and prop.limit
- Decrease corrosion resistance and ductility

ANNEALING

- Controlled heating and cooling process designed to produce the desired properties
- Annealing temperature is half the melting point of a pure metal or the fusion temperature of an alloy
- Increase softening, plastic deformation potential and improve machinability

- **Recovery**
Recovery of ductility and corrosion resistance
- **Recrystallization/Re crystallization Temperature**
Usually 1 hour in which the crystalline grain structure is revived. makes metal soft and ductile(suitable for clasps)
- **Grain growth**
- Occurs in a way to minimize grain boundary area with large grains consuming small grains. Coarse grain structure is produced

QUESTIONS:

DEFINE : COLD WORKING

ANNEALING

GRAIN GROWTH

Q/WHAT ARE THE MEDICAL APPLICATIONS OF TITANIUM ?

THANK YOU