Lecture 1, Jan 10, 2022

- Materials science:
  1. Understanding the structure and how it relates the properties of the materials and how to process the materials to have these properties
  2. Based on this understanding, select the right materials and recognize design opportunities
- Example: Hip implants: with age or illnesses joints with large loads such as the hip deteriorate
  - What material should we make the implant out of?
  - A lot of load, lots of loading/unloading cycles, needs to be biocompatible (the body can't reject it), can't be too heavy
  - Modern hip implants are primarily metallic (e.g. titanium) and very complex
  - Coatings attach the implant to the bone and allow the bone to grow around it
  - A ball joint allows movement
- Materials can be engineered to have properties we want; e.g. rapid cooling steel results in increasing hardness
- Types of materials:
  - Metals:
    * Strong and ductile
    * Lots of free electrons make it thermally and electrically conductive, and also opaque and reflective since EM waves are cancelled out by electrons moving in the metal
  - Polymers:
    * Covalent chains
    * Soft, light and low strength
    * Insulators
    * Translucent/transparent
  - Ceramics:
    * Ionic bonding (compounds of metallic and non-metallic elements)
    * No free electrons, so good insulators
    * Brittle
- The material selection process: Application →Properties →Candidate Materials →Required Processing
- Adding impurities can change material properties; e.g. adding nickel to copper increases resistivity; deforming it also increases resistivity
  - Sometimes we add impurities to copper intentionally to make cables more flexible – we need to balance aspects