

3.37 (Class 4)

Question: thermal diffusivity?

- Thermal Diffusivity (α) = Thermal Conductivity (k) / (density * heat capacity)
- Combined, or derived parameter
- From Fourier's 1st law and 2nd law (diffusion equation)
- $\Delta H = C_p \Delta T$

Question: Cold welding of semiconductors, is it gold-to-gold? Typically yes, gold pad

Discussion about World Trade Center and Pentagon:

- Why collapse? Structural members, lose part of the group, place more stress on the others, heat from the fire softens the steel, unzipping, once they let go then they bring down the other floors by impact loading from floors above
- Why no tipping? Not really any force that would create tipping. Building has a large inertia.
- Defense against terrorist attacks like this?
 - Dealing with people who are willing to die for what they believe
 - Have to be willing to pay the same price, have just as strongly held beliefs as this person.
 - Goes back many years: Why British not able to defeat the colonials? Same about Vietnam. Afghanistan like Vietnam to Soviets. Fighting for homeland.
- People have a harder time dealing with man-made disasters than natural disasters.

Review:

- Contamination, rough surfaces and interfacial voids limit the strength of many joints
- Liquids are often used to overcome surface roughness (adhesive bonding, soldering, brazing, fusion welding)
- Interfacial shear is required for mechanically produced joints
- Langmuir is 10^{-8} atm*sec
 - pressure*time product for one monolayer of atoms to strike the surface
 - (also need to account for sticking factor, probability that stays when hits, for oxygen and metal this will be quite high, say 0.8)

Contact are under normal loading never exceeds 1/3 apparent area

Story: In 1980 working with test lab (guy inherited business from father, had a correspondence degree). Had seen a news account of tornado where chickens had all feathers taken off. They decided low pressure of tornado that did it and tried to use a vacuum chamber to pluck a chicken ☺.

- Project to lay down weld metal to build up a part a little at a time.
 - Can get significant improvement in properties.
 - Can lay down say 5-500lbs per hour (thermal conductivity).
 - Can create large specialized parts, say to replace casting,
 - Very expensive
- Navy project using electron beams to destroy incoming missiles at short range
 - Hose instability, forms helical distortions
 - Only about 30" in aiming the beam
 - So instead tried to use it for welding

Today:

Surface Energy

- Metals on order of 1.0-1.5J/m² (
- Ceramic on order of 0.5 J/m²
- Polymer on order of 0.02 – 0.1 J/m²
- Metals have much higher surface energy than ceramics and much, much higher than polymers
- Polymer are van der Waals bonds (about 1/5 as strong as ionic or covalent bonds)
- Metals can be 2-3 times higher than either covalent or ionic bonds
 - Covalent bonding, between 2 atoms
 - Ionic bonding, charge transfer
 - In metal, electrons free to move, electrons participating in bonding can be felt much deeper into the surface
 - Diagram of model of the surface
- Metals very good at sucking up contamination from the air, surfaces very active, can do lots of work on the electrons
 - Catalyst in car
- Polymers are difficult to bond, if want to keep from bonding, typically put a polymer (like oil) to prevent bonding
- Teflon one of the most difficult things to bond to.
- Handout with surface energies
 - Water (hydrogen bond)
 - Teflon
 - Copper

Back to question of gold contact bonds

- Actually get better bond in intermediate donut region of maximum shear
- Diagram on board

Ultrasonic welding:

- Diagram on board
- 20-100kHz is typical bonding frequency
- have a small displacement oscillating back and forth
- microscopic shears

- contamination stays there
- may only have 50% bonded area since did not extrude contaminants, just buries it
- don't deform the substrates
- most commonly used on plastics
 - low thermal diffusivity
 - doesn't take as much energy to do this
- big horn driven by oscillating source, transferred to smaller horn with large taper radius to increase displacement, magnification of stress wave

Rotational Friction Welding

- Friction stir welding
- Good for aluminum
- people trying it on titanium
 - rod material tungsten or molybdenum

Linear Friction Welding

- Air Force trying to take weight off of turbine blades (see diagram on board)
- Flange and Christmas tree structure
- Any type of mechanically fastened joint is very heavy
- Looking at linear friction welding, nickel-based superalloys to weld this joint
- Apply downward force and slide two pieces together
- Scrap costs are horrendous, no good repair procedure
- "blisk" = bladed disk
- can eliminate 2000 lbs per fighter