

3.37 (Class 7)

Review

- Book on explosive welds
- Wire Bonding
 - Diagram on board (squeeze wire-thermal compression weld)
 - Perimeter Bonding
 - Up to 200-400 I/O (approx 50 per side, can make double rows but lose real-estate on semiconductor)
- TAB Bonding
 - Diagram on board
 - Solder connection (gold and tin-plated connection, use a heated platen of tungsten or aluminum, perhaps molybdenum)
 - Perimeter Bonding
 - Up to 400-800 I/O (approx 100 per side)
- Controlled Collapse Chip Connection (C4)
 - Diagram on board (internal connection of silicon chip to substrate with small solder balls, tin or indium-tin, sometimes around lead which doesn't melt so that chip stays above substrate, about 4mil)
 - Balls help to self align by surface tension
 - Ball Grid Array, sometimes refers to the connection of package to circuit board, distinction between C4 and BGA becomes blurry when chip gets mounted directly to the board.
 - Don't get much bigger than 1cm per side on chip due to thermal expansion
 - Invented in 1960's by IBM, just come into its own
 - 1000-2000 I/O
 - Area Bonding (lose some real-estate, but distributed throughout)
- Size of chips and speed
 - Speed of light = 3×10^8 m/s
 - $\lambda = c \cdot t$
 - Say 3GHz
 - $\lambda = 0.01 \mu\text{m} = 10\text{nm} = 1000\text{angstrom}$
 - Even if electrons going at speed of light, signal can't even get off the chip
 - But only going at about 10% of the speed of light, has to do with the reactance (mostly capacitance) of the chip.
 - Alpha chip at 1GHz required special electromagnetic design
 - One of the ways around this is to use clockless computers, supposedly able to get a 2-3x increase in speed.

Today

Adhesive Bonding

- Unique among welding and joining processes
- Only one that just buries the contamination+

- For copy machines, essentially bonding toner to paper
 - Company X, book starts with “gluons”
 - Similar to starting with diagram of binding energy between atoms
 - But don’t need to start at this level in adhesive bonding
- Start with surface, then add contaminants
 - Oxides (very quickly forms)
 - CO₂
 - H₂O
- Need something that has a lower surface energy
 - Problem bonding to Teflon
- Types
 - Type I
 - Diagram on board
 - Two pieces of solid, interpose a liquid that “wets” the surface
 - Separation distance d , radius of curvature r
 - See formula on board
 - Soap bubbles obey this equation
 - Blowing up balloons, need more pressure to start the balloon, small curvature
 - Adjust for spherical or cylindrical bubbles
 - Negative pressure in wetting liquid
 - Demonstration with Johansen blocks (used by machinists), very precisely ground blocks, accurate to about 50millionths of an inch, slide together and they adhere, use oils from hands as the liquid, even chalk dust can interfere with this bond
 - Type II, Mechanical Interlocking
 - Two rough surfaces with liquid that hardens yields a mechanical bond
 - Say 90+% of bonds are just mechanical interlocking
 - Teflon mechanically interlocked into a porous surface
 - Demonstration with “Magic Sand”

Wetting

- Young’s equation
 - Diagram on board
 - Angle formed at solid-liquid-vapor interface
 - Used when get to solders
 - One of the simplest and most misunderstood equations
 - An equation at equilibrium
 - Water on waxed car has high theta
 - Adding wetting agents in automatic dishwashers to cause “sheeting action”
 - Mercury (toxic), can use gallium (not as toxic as mercury, melts in your hand)