# IME 156 Week 3

- Good morning,
  Please sit with your group.

# PCB Assembly - Objectives

1. Distinguish between surface mount (SM) and through hole (TH) package types.

2. List advantages of, and applications where SM or TH would be chosen.

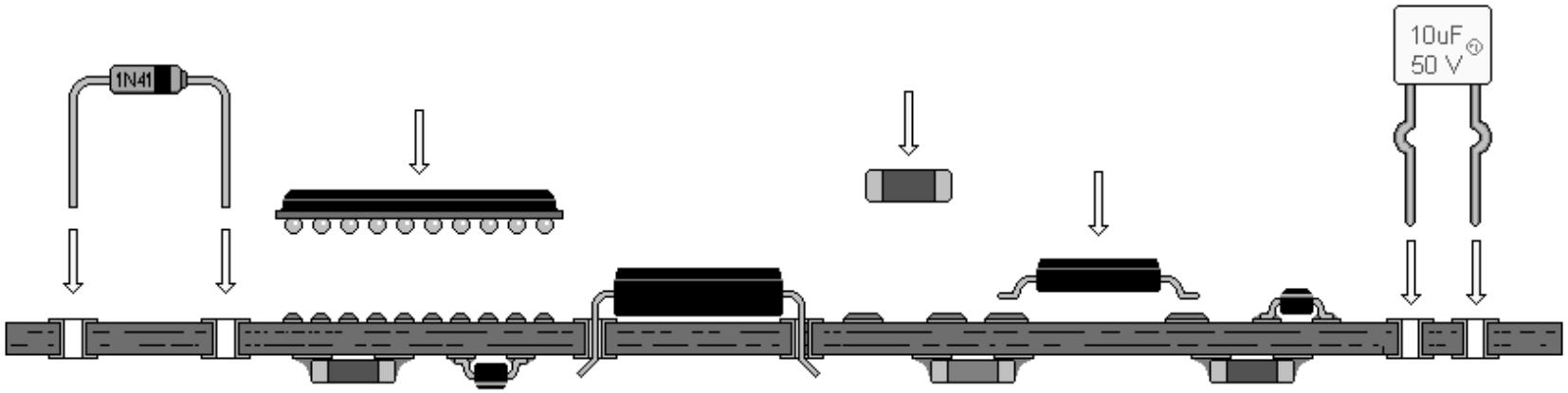
3. Identify several types of common packages from their appearance.

4. Determine the dimensions of discrete surface mount components from their part type.

5. Rank package lead styles by the most efficient design.

# PCB Assembly

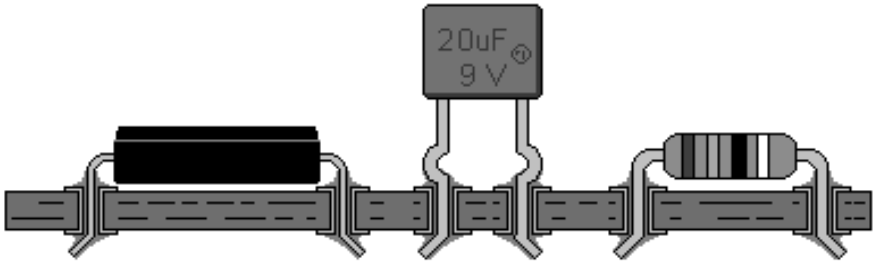
Process of mounting & soldering various component types onto a PCB.




"Mixed assembly" = PCB with both through-hole (TH) & surface-mount (SM) components

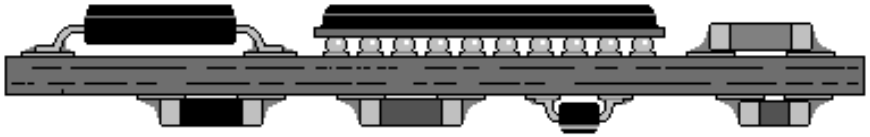
# Component Types

- **Through-Hole:**
  -Large / heavy components
  -Large current-capable components
  -Fasteners & connectors




Through-hole assembly

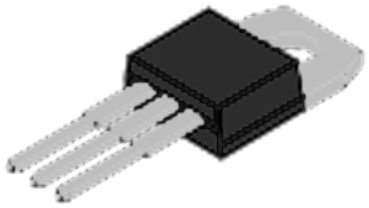
- **Surface Mount:**
  -Smaller, lighter, low-cost
  -Lower footprint (use less board space)
  -Fewer holes to be drilled
  -Simpler automated assembly



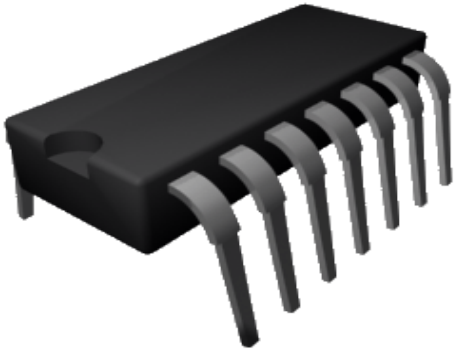
Surface Mount Assembly

# Through-Hole Integrated Circuits (ICs)

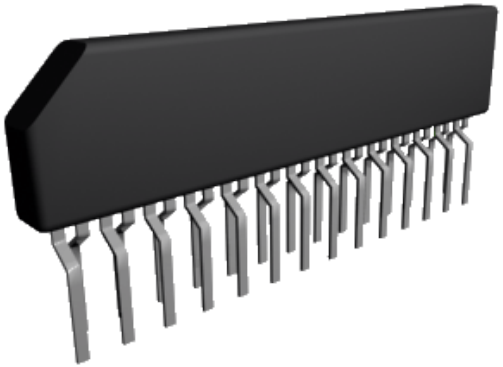
**Discrete**: TO-220
'Transistor Outline'
Style 220



*DIP
Dual-Inline Package



ZIP
Zigzag-Inline Package

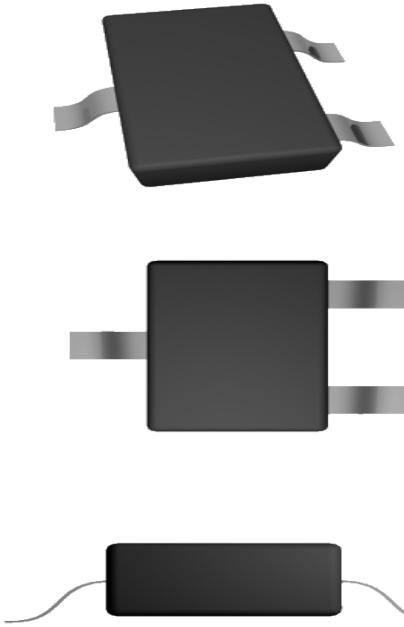


***DIP** - Most Common Thru-hole IC Package

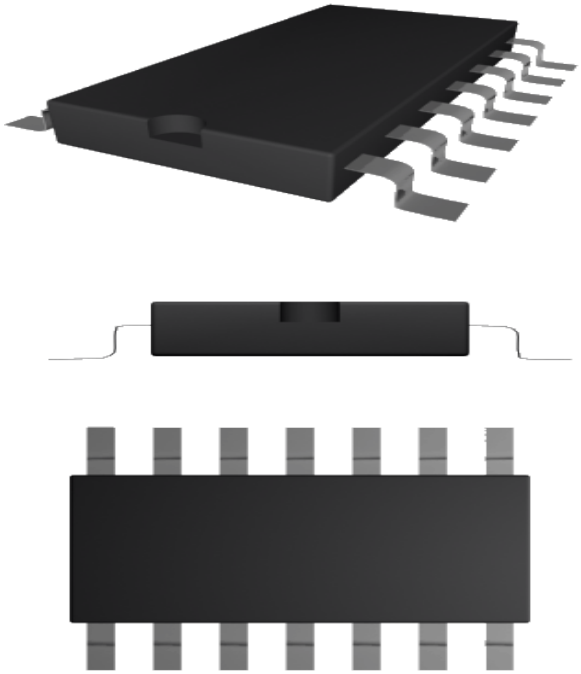
# Surface Mount ICs

- Lead Styles
  - Size & Shape
    - Lead shape (Gull wing, J lead, butt or I lead, solder ball)
    - Evolved to populate both sides of board, minimize area
- Common Package Shapes
  - SOT, Small Outline Transistor
  - SOIC, Small Outline IC
  - PLCC, Plastic Leaded Chip Carrier
  - QFP, Quad Flat Pack
  - BGA, Ball Grid Array

# SOT & SOIC
# ‘Gull Wing’ Leads

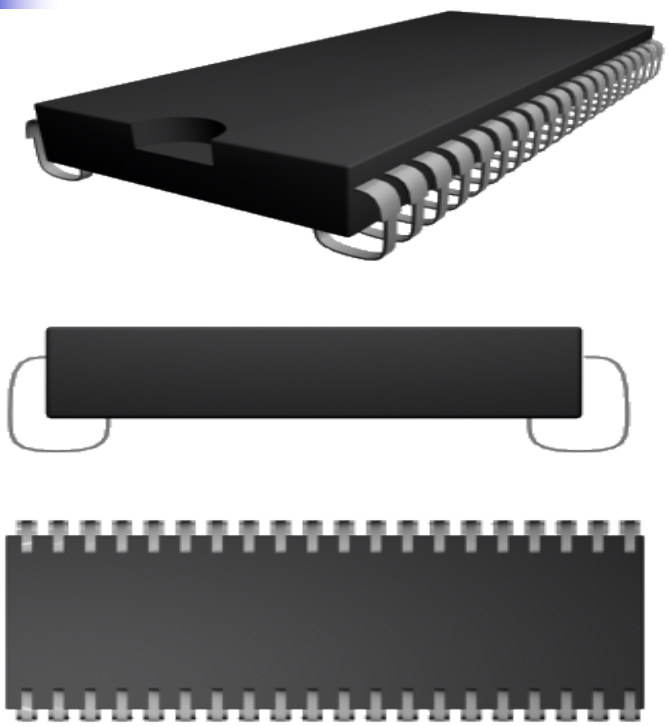


SOT - Small Outline Transistor

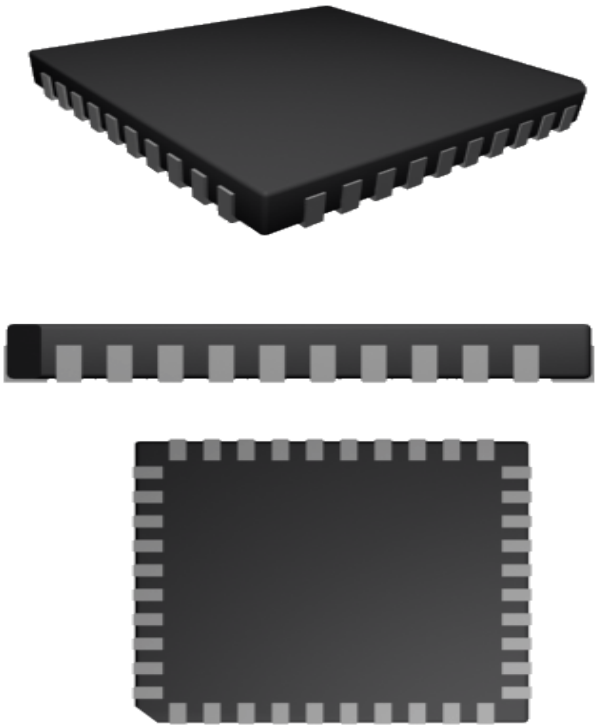


SOIC - Small Outline Integrated Circuit

# SOIC & PLCC - J lead & I lead

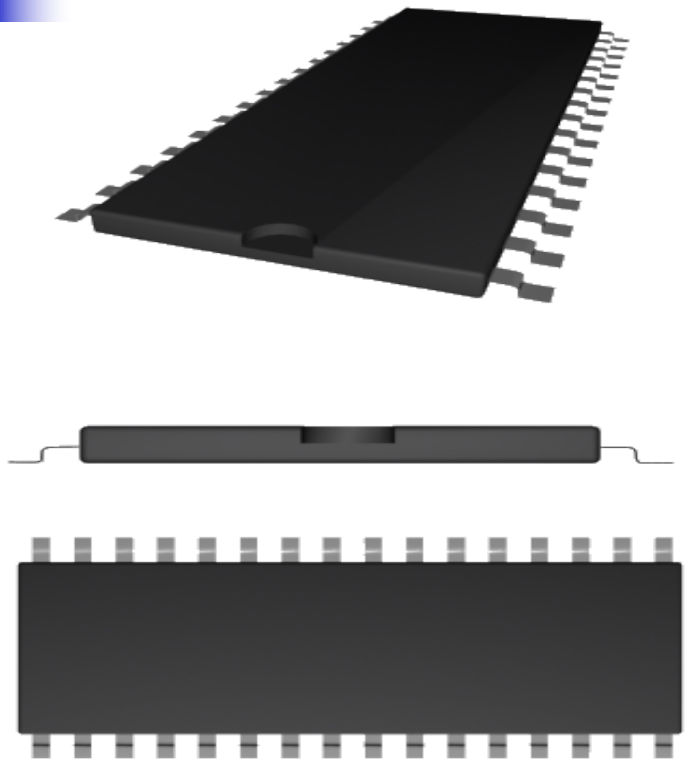


SOIC with J Lead Configuration

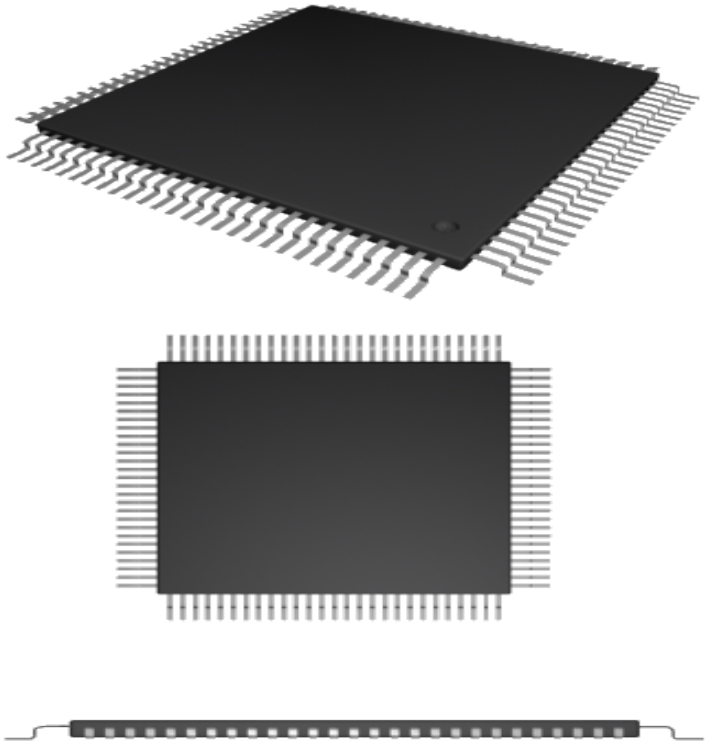


PLCC with I Lead Configuration

# TSOIC & QFP - Gull Wing

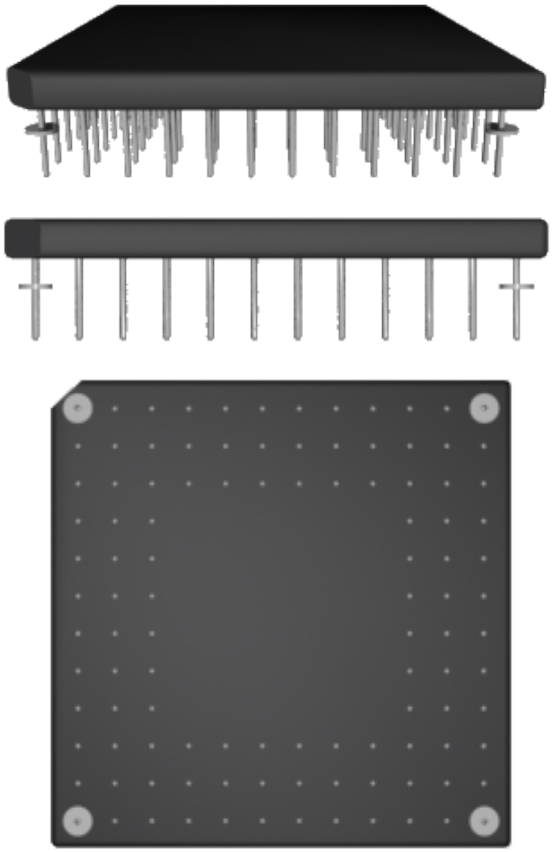


Thin SOIC with Gull Wing Leads

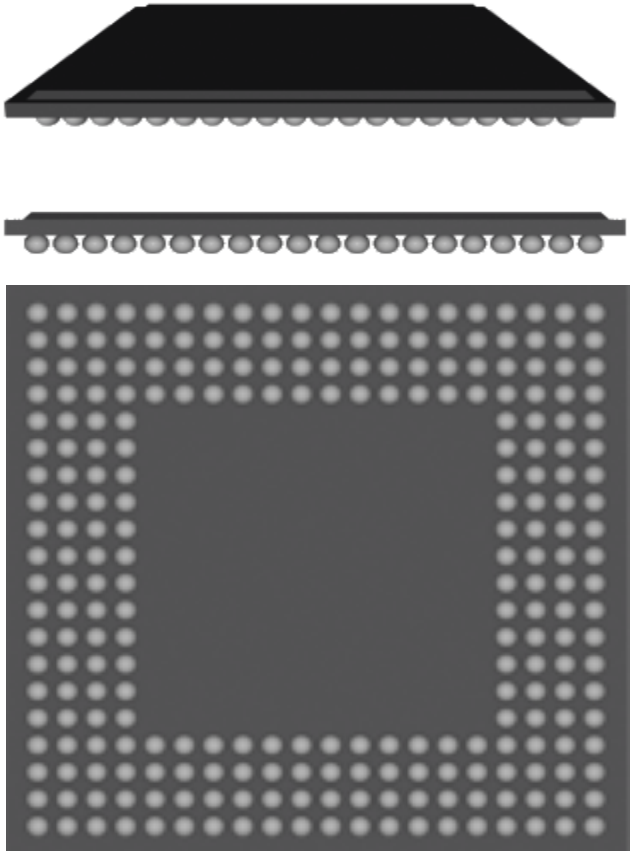


Quad Flat Pack with Gull Wing Leads

# PGA & BGA



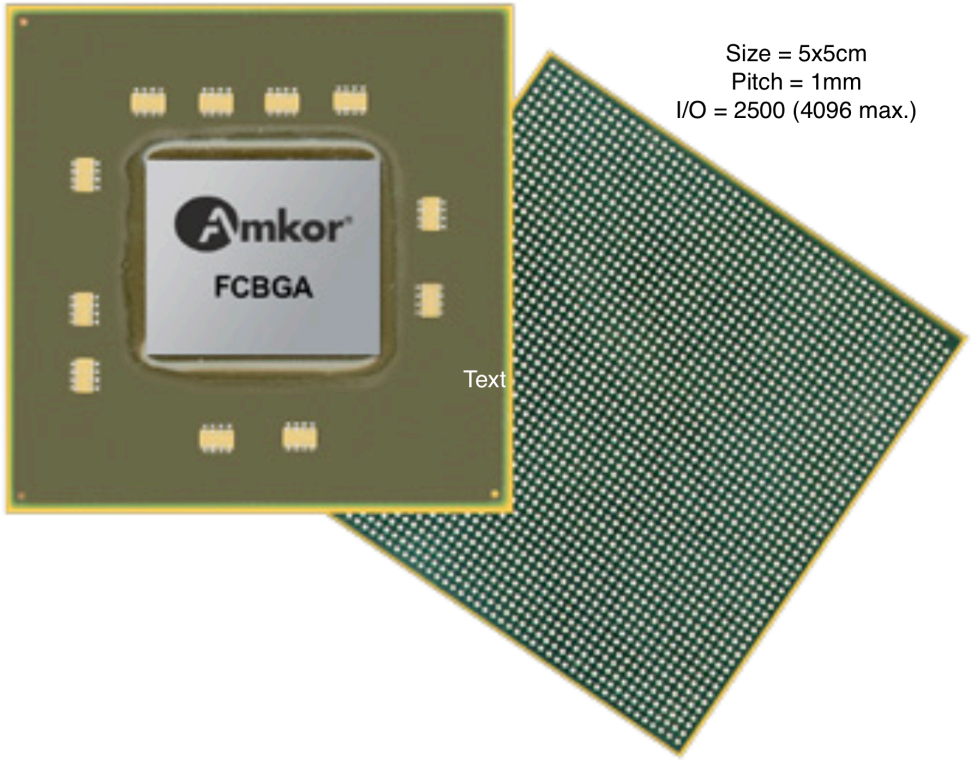
Pin Grid Array



Ball Grid Array

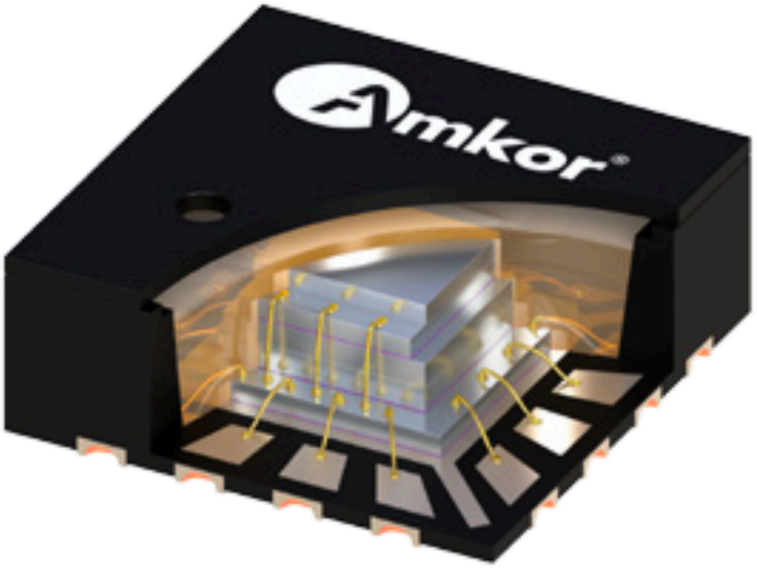
# Modern QFP, BGA


Quad Flat Pack

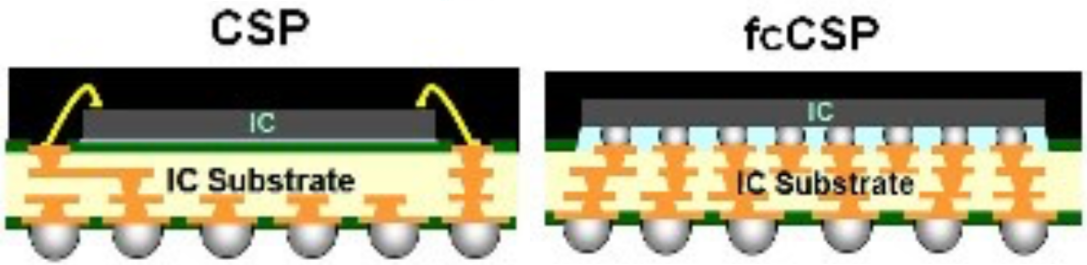



Ball Grid Array

# Flip Chip CSP & MEMS


Stacked-Die MEMS




Chip Scale Package & flip chip - Chip Scale Package
CSP: Package = 120% of Die Area

# Flip Chip CSP Example

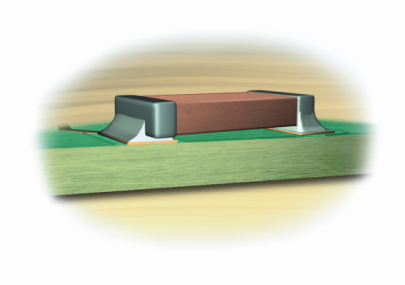

CSP Definition: Package = ~120% of Die Area

For an IC Chip Scale Package (CSP) with die size 900 $mm^2$, approx. how large would the package be?

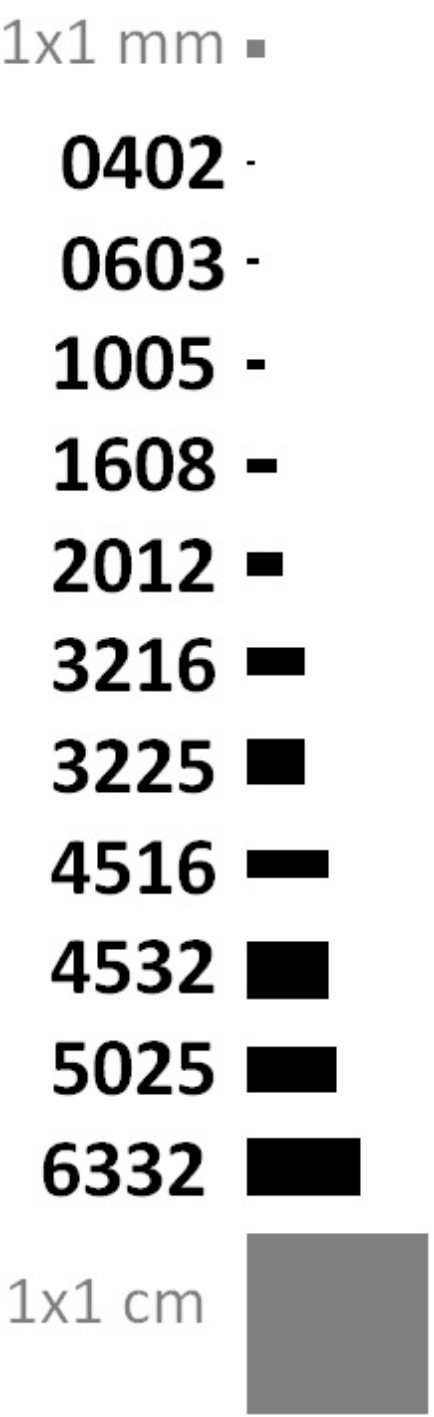
For CSP, Package = 120% of Die Area.
So,
Package size = 900 $mm^2$ x 1.2 = ~1080 $mm^2$
(**Not much bigger than the die**!)

# Surface Mount Discrete Components

- Resistors, capacitors & inductors
- Common Package Sizes:
  - 0402
  - 0603
  - 0805
  - 1206



- 0805 = 80mils X 50mils, L X W
  (mil = thousandth of an inch)



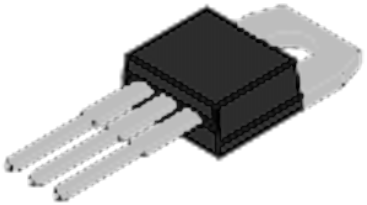
# Quiz: Are these packages Surface Mount or Thru Hole?

1. TO-220 Voltage Regulator
2. 0805 Resistor
3. Gull wing QFP
4. 8-pin DIP
5. BGA
6. J-Lead PLCC

# Quiz: TH or SM for these applications?

1. Multi-pin connector
2. Automated assembly
3. High component density
4. Dual-sided assembly
5. Must be easily re-workable

# Quiz: Identify these packages and lead types

1. 
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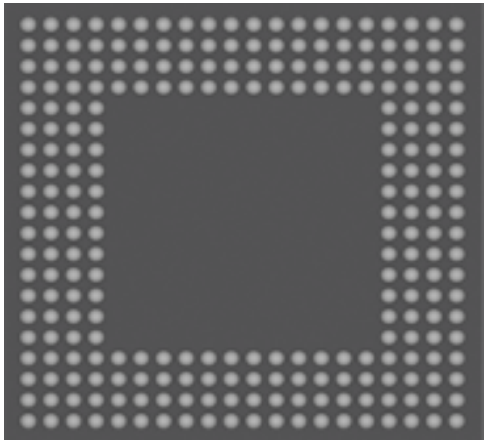
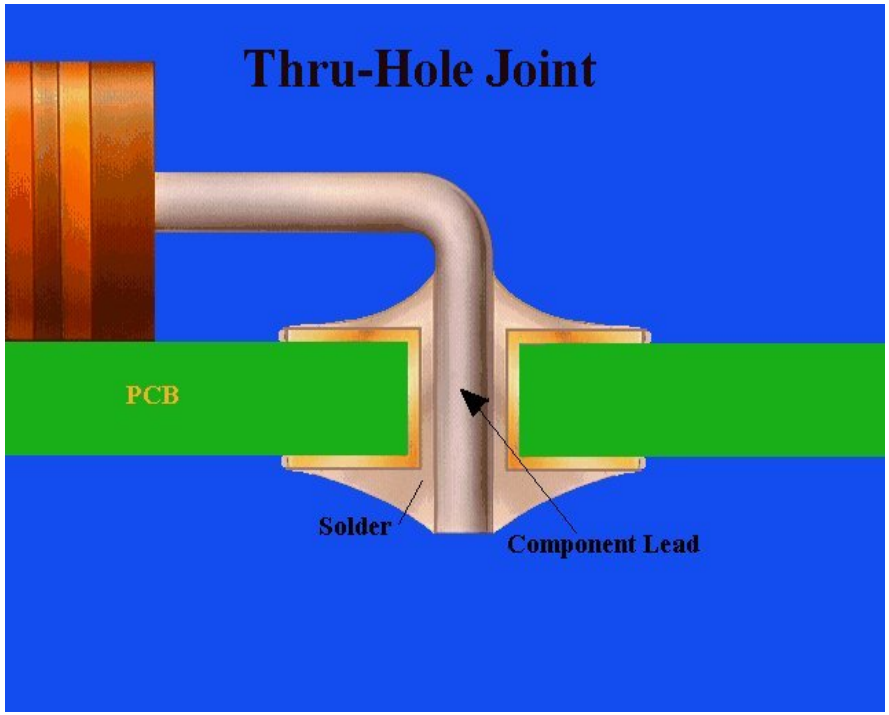
3. 

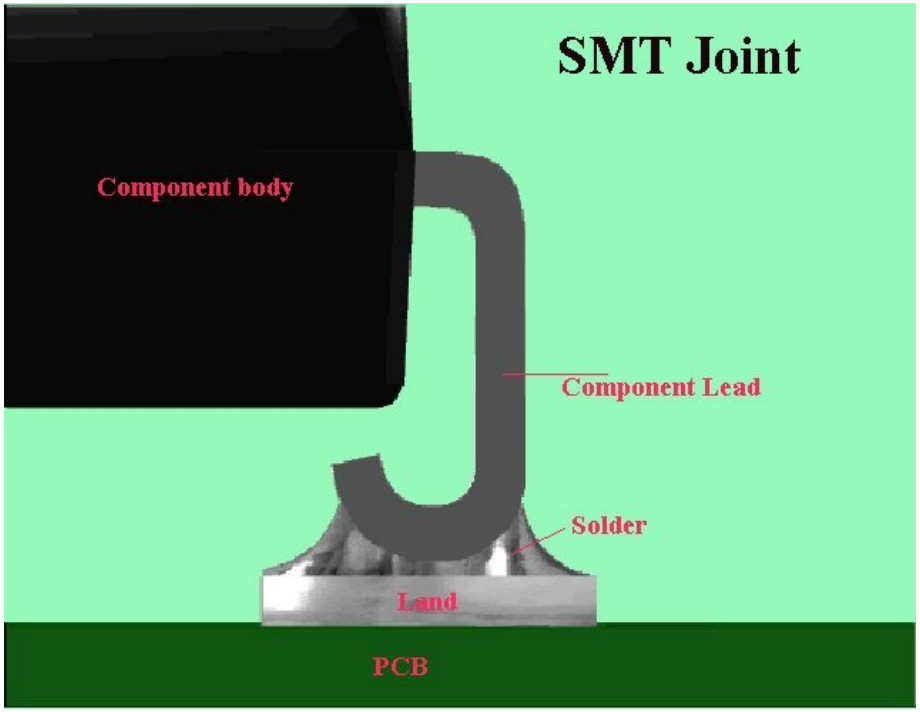
# PCB Assembly - Attachment

- Soldering
  - Purpose: Create a reliable electrical, mechanical & thermal connection.
- Solder
  - Metal alloy typically consists of tin & lead.
  - Most common solder (60% Sn / 40% Pb)
  - Eutectic solder (63% Sn / 37% Pb)
- Flux
  - Purpose: Reduce surface oxides
- Solder Paste
  - Mixture of solder powder, flux and a solvent

# Soldering

A good reliable solder joint has the proper amount of solder and appears shiny and smooth.



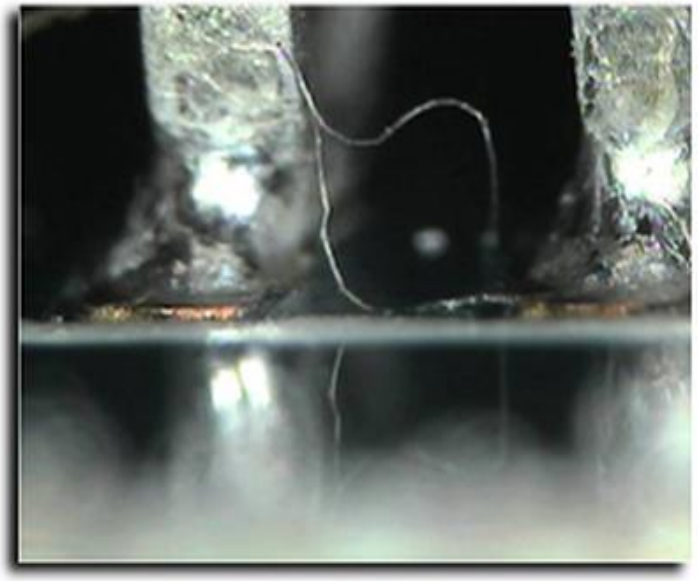




Reference: Workmanship requirements for NASA hardware - https://workmanship.nasa.gov/lib/insp/2%20books/frameset.html

# Lead-free Solder

- RoHS – Restriction of Hazardous Substances
  - Took effect July 2006 in Europe
- California started prohibiting sale of electronic devices under RoHS-like in 2007
  - Narrower scope of products
- Federal RoHS-like regulation unlikely anytime soon
- Our lab choices: 60Sn-40Pb or Sn-.5Ag-4Cu

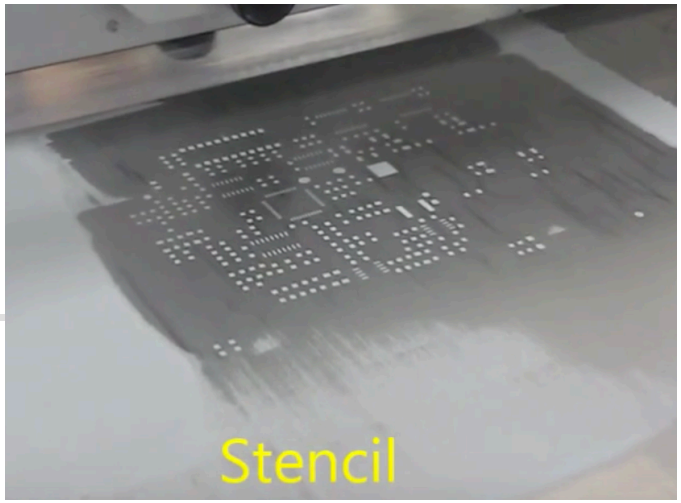
# Lead-free Solder



- Pros:
  - Environmental
  - Less surface tension, "stays in place" = tighter pad spacing
- Cons:
  - Negative effects on reliability (cracking, "**tin whiskers**") & high cost of compliance

# A Disturbing Case of Tin Whiskers

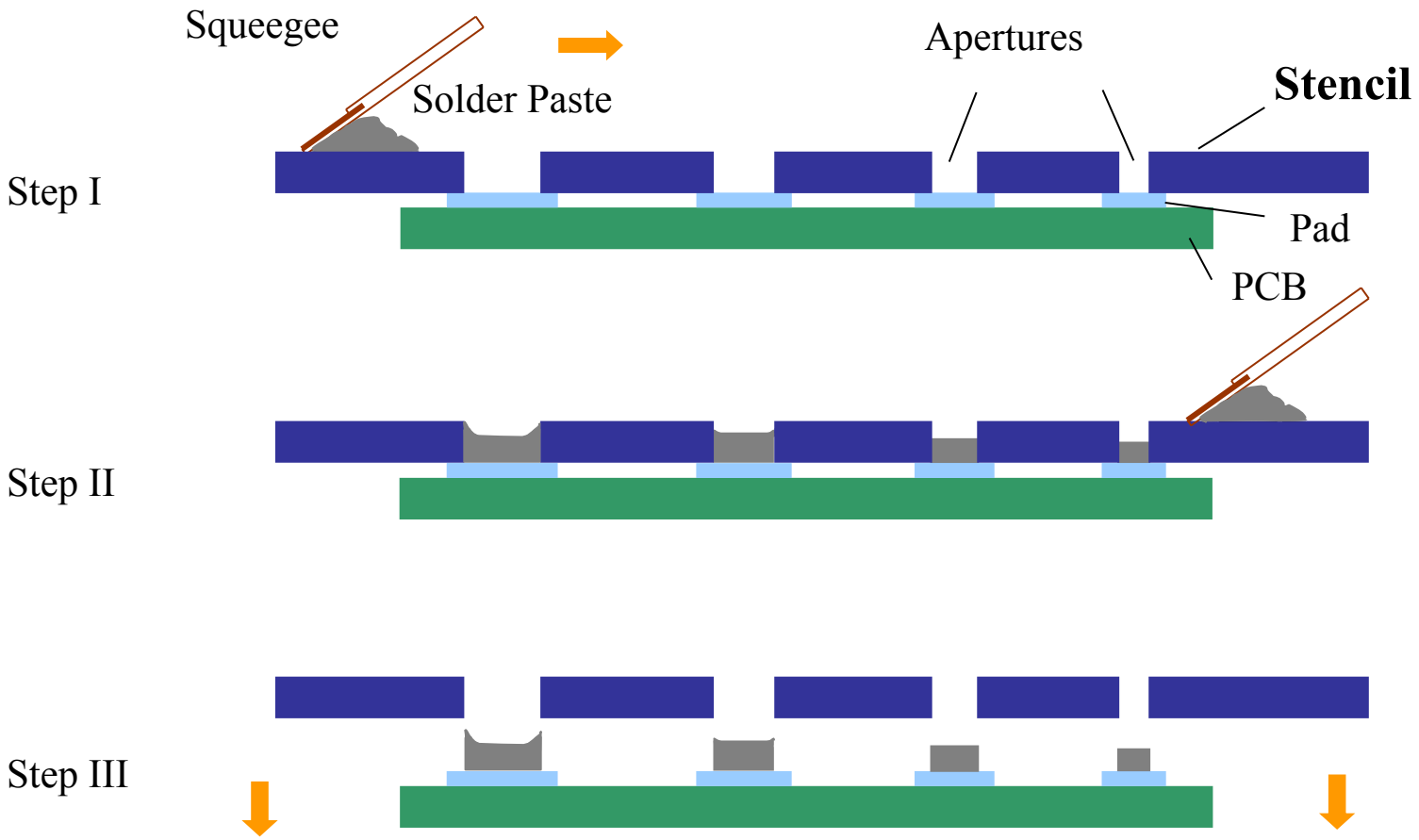
# PCB Assembly



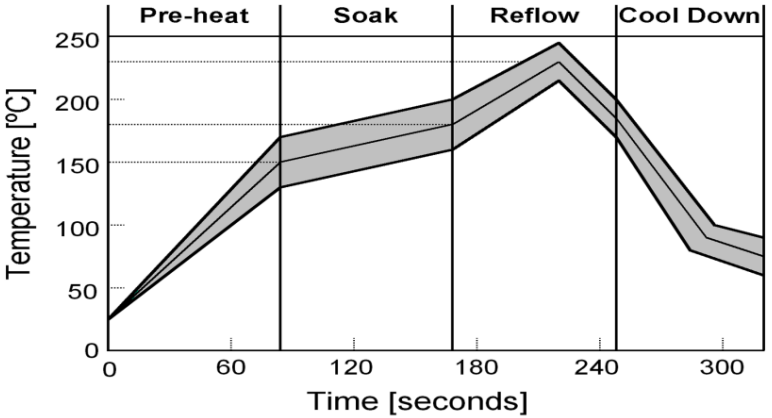

- Surface Mount Assembly Steps
  - Solder paste printing
    - Metal stencil is used to place paste on soldering surfaces.
  - Component placement
    - Typically automated with optical alignment utilizing fiducials*.
  - Reflow soldering
    - Process where solder is placed on solder pads before heat is applied.
    - Melting of solder is accomplished inside either IR or forced-air convection oven.

**Fiducials* are board markings near the PCB corners which allow the pick & place machine to locate the PCB in space very accurately.

# Solder Paste Printing

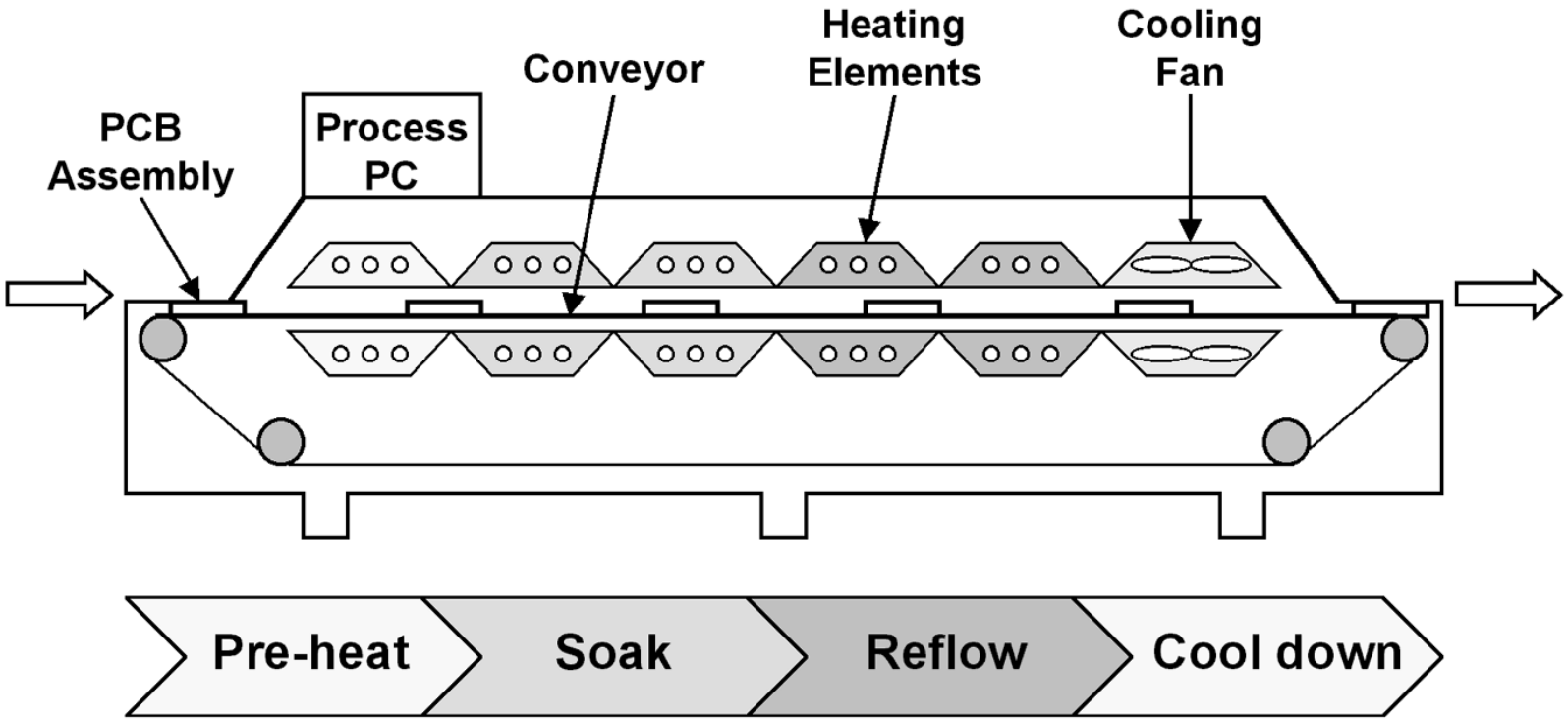


# Reflow Soldering




Reflow Temp-Time Profile

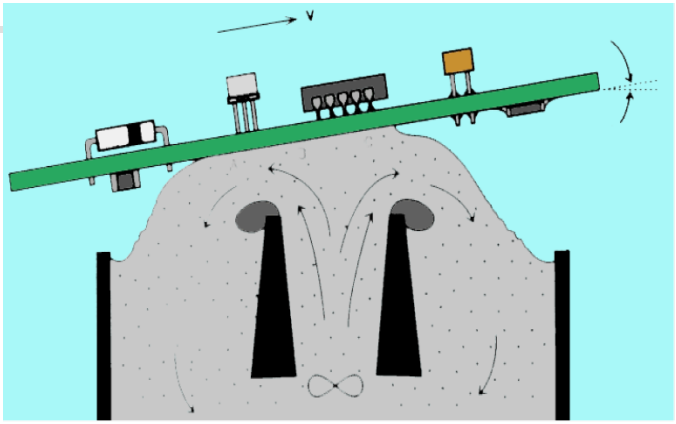
5 heating zones & 1 cooling zone



# Methods to melt solder in SMA

- Forced-Convection (Circulating hot air)
  - Cheapest, most common
  - Board thermal symmetry considerations
- IR – Infra Red (IR energy)
  - Expensive
  - Heat transfer dependent on component color & surface
  - Component placement critical (shadowing)
- Vapor-Phase (Hot gas)
  - Latent Heat of Vaporization
  - Best solder joints
  - Environmental concerns (florinated hydrocarbons)

# PCB Assembly



- Through-Hole Assembly Steps
  - Component placement
    - Automated or manual.
  - Wave soldering or soldering iron
    - Process where PCB is passed over molten solder wave. Solder adheres only to metal surfaces not covered by mask.
    - Unlike reflow soldering, solder applied as a liquid.

# Bare & Assembled Mobile Phone PCB