Speaker

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- Graduation:
  - Electrical Engineering - NED University Karachi 1982
- Employment History:
  - Zelin Limited- Karachi
  - Digital Communications (Pvt.) Ltd Sr. Engg. Manager 1983-1996
  - Creation Technologies – Vancouver, Canada Process Engineer 1997-2000
  - ConnectCom Inc.- Los Angeles, USA Test Eng. Manager 2000-2002
  - Creation Technologies - Toronto , Canada Engg. & Quality Ldr. 2002 -
- Others:
  - Six Sigma Green Belt
  - Lead Auditor Medical Systems
  - Author of 2 papers in advanced manufacturing technology

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Purpose

- Why this seminar
  - Rapid growth of electronic manufacturing in past two decades
  - Pakistan's adoption of surface mount manufacturing technology
  - Awareness to adopt SMT

Agenda

1. Electronic Manufacturing
2. Manufacturing Technology
   - Electronic Components
   - Assembly Equipment
   - Assembly Materials
   - Soldering
3. State-of-The-Art Technologies
4. Manufacturing Standards
5. World Class Manufacturing – Lean Principles
6. Electronic Assembly Business (cost, benefits, outsourcing)

Ticklers

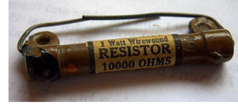
Modern conspiracy theories

- Why was JFK assassinated
- AIDS virus was developed on purpose
- Who was responsible for 9/11
- Was the book held upside down on purpose
- Is the moon landing fake
- Truth about Princess Diana's death
- Facts behind the assassination of the four leaders of Pakistan
- Do aliens really exist and have they ever been captured
- Is Area 51 real
- Was there really a UFO crash at Roswell, NM in July 1947

How Roswell revolutionized electronics

History of Electronics

- Classic electronic components- 1960s
  - Resistor
    - Typical size: 1"

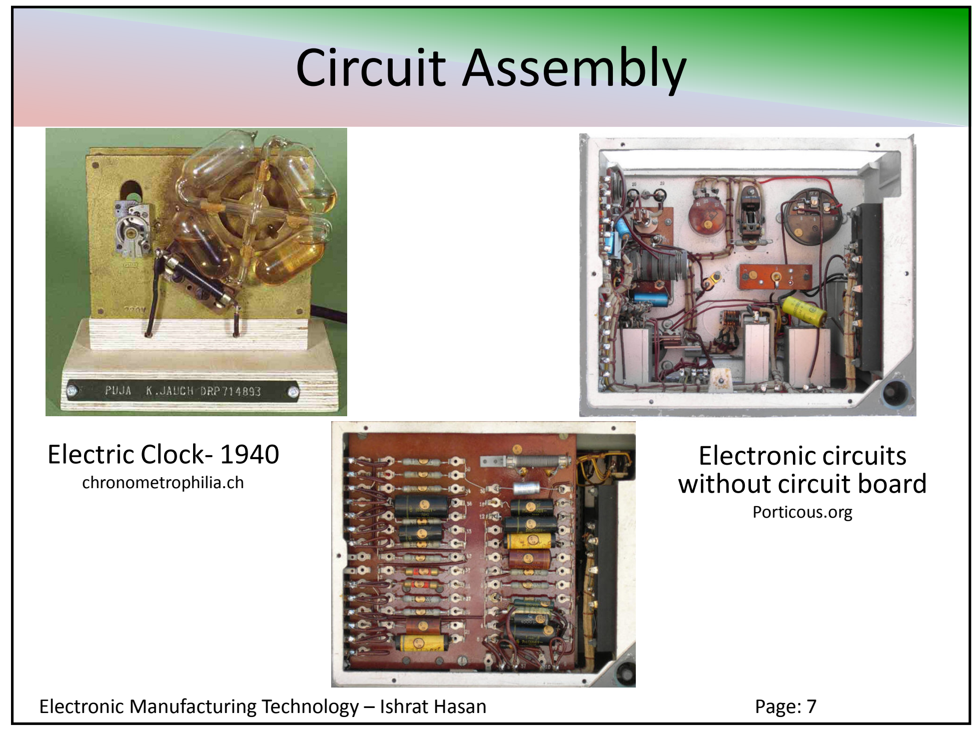


  - Condenser
    - Typical size: 1"

  - Valves
    - Diode
    - Triode
    - Pentode

Amateurradio.org

tablix.org



Electronics Today

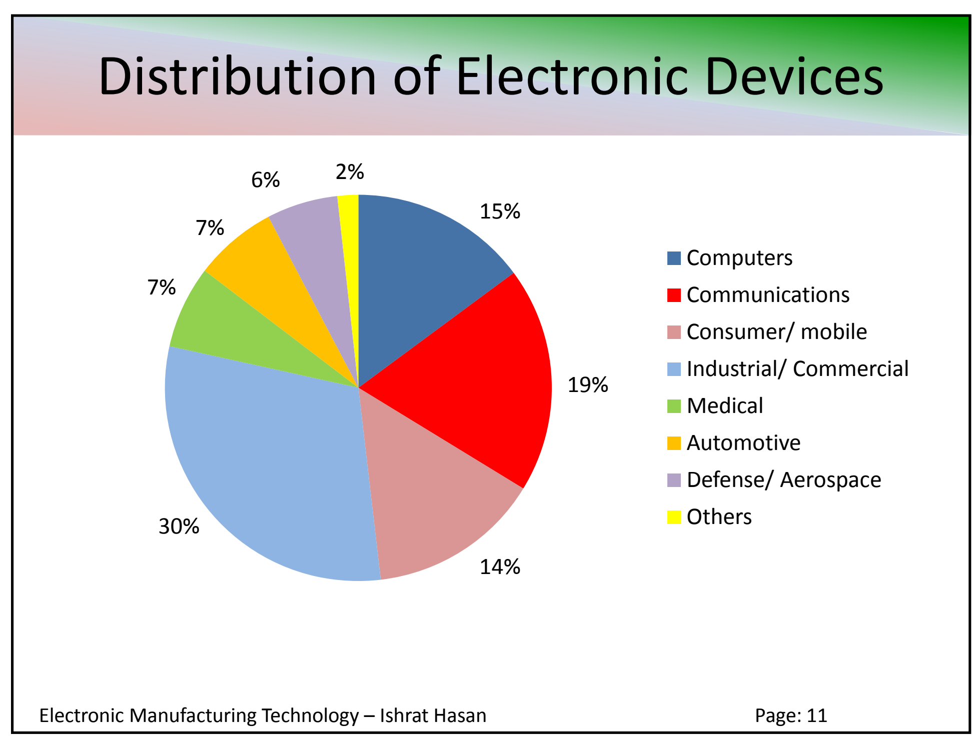
- Where electronics can be found?
  - Industry
  - Space
  - Transportation
  - Homes
  - Toys
  - Offices
  - Sports
  - Military
  - Medicine
  - Inside the humans
  - Religion

Electronics Today

- Electronic is one of the largest industry in the world
- Revenue from electronics is over trillion dollars a year
- Forecast for electronic manufacturing turnover is $1.8 trillion in 2012.
- Outsourced electronic manufacturing revenue forecast for 2012 is $220 billion.
- Most of this revenue is centered around (in the right order)
  - Far East (Taiwan, Singapore)
  - North America (USA, Canada)
  - Europe
  - Far East (China, Japan, Hong Kong)
- Pakistan has negligible share in this industry

Trend of Electronic Manufacturing

- The world has significantly moved towards contract manufacturing
- All leading electronic gadgets in the world are manufactured at contract manufacturers facility
- Contract Manufacturers have played a key role in the development and advancement of manufacturing technology
- Contract manufacturing has helped making electronics affordable by offering reduced and competitive cost through
  - Consolidation of capital cost of equipment
  - Development of expertise in manufacturing
  - Leverage of purchasing power for parts
  - Offering zero inventory liability***



Agenda

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   - Assembly Equipment
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5. World Class Manufacturing – Lean Principles
6. Electronic Assembly Business (cost, benefits, outsourcing)

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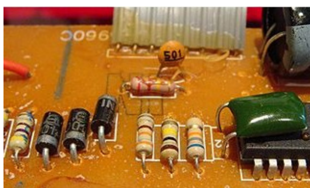
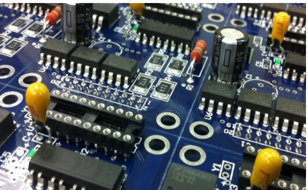
Types of Electronic Assembly

- By design/manufacturing techniques
  - TH: Through Hole
  - SMT: Surface Mount Technology
  - MT: Mixed Technology (SMT+TH)
- By configuration
  - Single sided: SMT TH MT (SMT+TH)
  - Double sided SMT MT (SMT+SMT+TH)





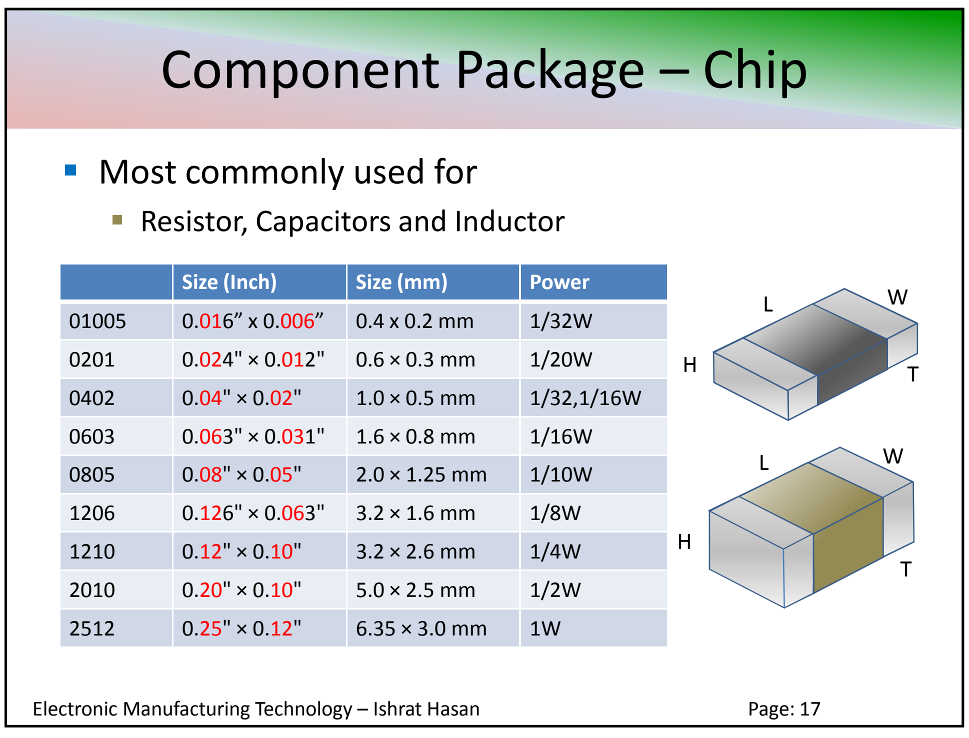
Electronic Components

Electronic Components by Function

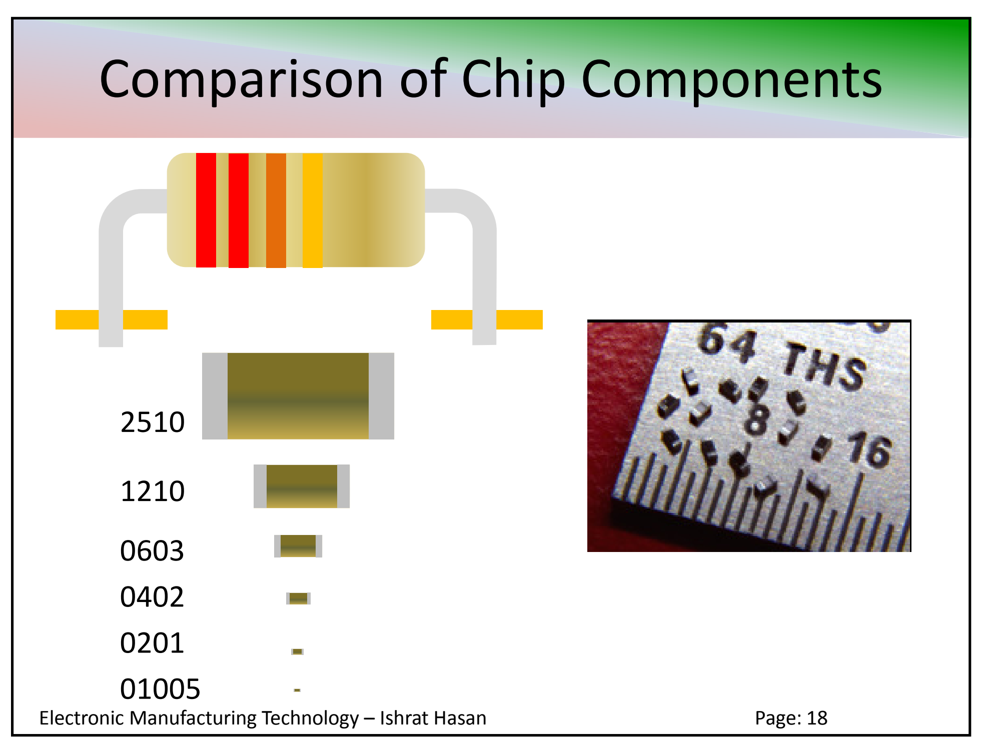
Common devices	Others
Resistor	Optical devices
Capacitor	Relays
Inductor	Switches
Diode	Displays LCD and LEDS
Transistor	Interconnects and sockets
Regulators and Power Devices	Crystal
• Semiconductor • Logic • Analog • Processor • Memory • Hybrids	Magnetics • Transformer • Ferrites

Electronic Components by Packages

	Through Hole	Surface Mount
Passives component	Axial or radial :Resistor, Capacitor, Diode, Inductor	Chip: Resistor, Capacitor, Diode, Inductor,
Semiconductor packages	DIP, SIP, PGA	SOT, SOD, SOIC, TSOP, SSOP, DPAK, QFP, TQFP, QFN, LGA, BGA, CGA
Lead pitch	Common: 0.1”]2.54mm] Min: 0.05” [1.25mm]	Common: 0.02” [0.5mm] Min: 0.016” [0.4mm]
PCB technology (to complement the package type)	4-6 layers Traces: 0.01” [0.25mm], Pads: 0.05” [1.2mm]	20 layers Traces: 0.004” [0.1mm] Pads: 0.02” [0.5mm]
Component attachment method	Semi automatic or Machine insertion	Pick and place
Soldering	Hand or Wave soldering	Solder paste print and reflow soldering
Placement sides	Mostly on one side, manually on other side of the board	Evenly distributed on both sides of the board



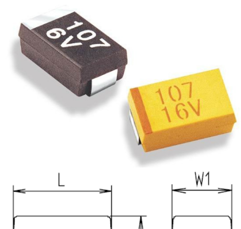
	Size (Inch)	Size (mm)	Power
01005	0.016" x 0.006"	0.4 x 0.2 mm	1/32W
0201	0.024" × 0.012"	0.6 × 0.3 mm	1/20W
0402	0.04" × 0.02"	1.0 × 0.5 mm	1/32,1/16W
0603	0.063" × 0.031"	1.6 × 0.8 mm	1/16W
0805	0.08" × 0.05"	2.0 × 1.25 mm	1/10W
1206	0.126" × 0.063"	3.2 × 1.6 mm	1/8W
1210	0.12" × 0.10"	3.2 × 2.6 mm	1/4W
2010	0.20" × 0.10"	5.0 × 2.5 mm	1/2W
2512	0.25" × 0.12"	6.35 × 3.0 mm	1W



Component Package – Tantalum

- Tantalum
  - Package supports Capacitors and Diodes
  - Range from 4v to 35v; up to 470µF

Code	EIA Code	Size LxW mm	Size H mm
J	1608	1.6 x 0.60	0.85
P	2012	2.0 x 1.25	1.2
A	3216	3.2 x 1.6	1.6
B	3528	3.5 x 2.8	1.9
C	6032	6.0 x 3.2	2.5
D	7343	7.3 x 4.3	2.8

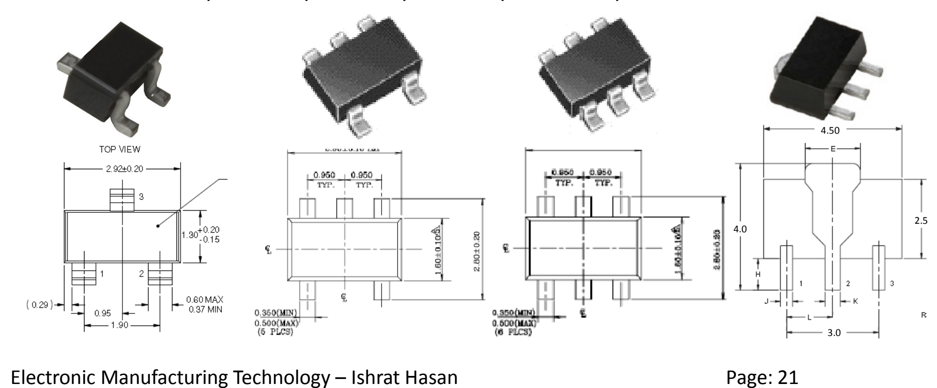


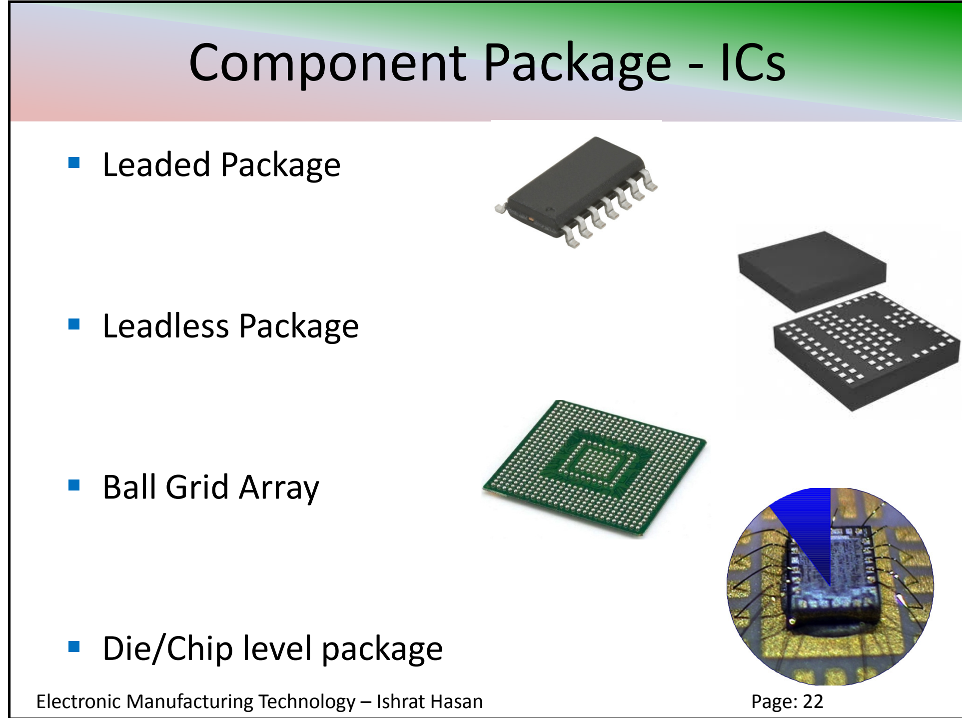
Component Package – MELF

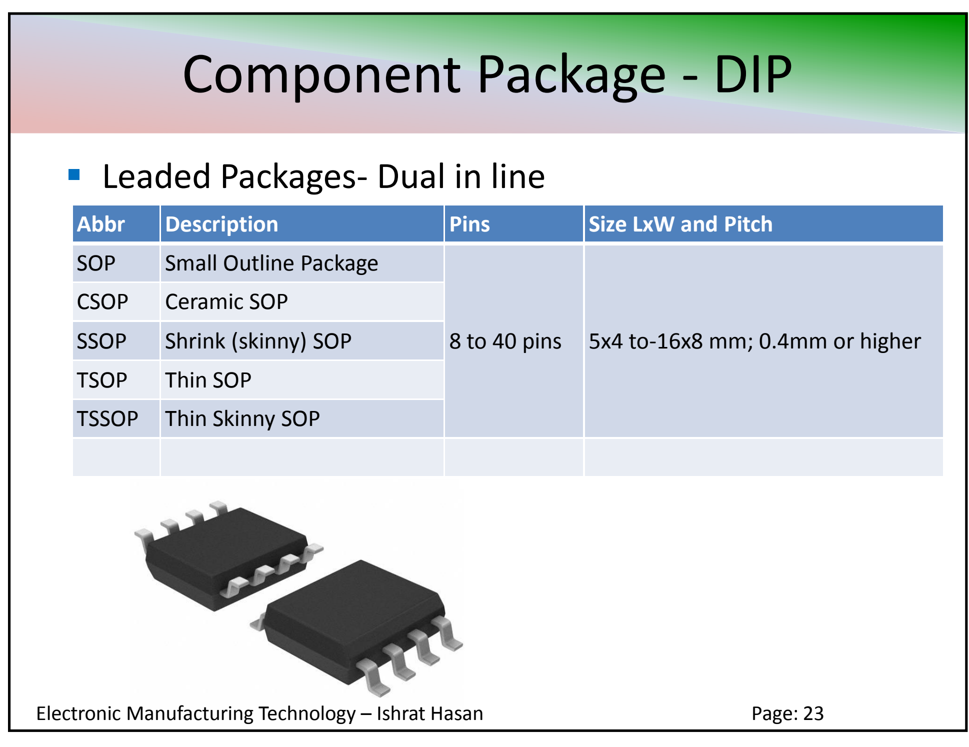
- MELF
  - Used for diodes
  - Black band represents Cathode
- Typical size
  - 5.0 x 2.5 mm

Component Package – SOP

- Small Outline Package: SOT: Transistor or SOD: Diode
- Used for transistors, diodes or other power devices
- Package Types:
  - SOT23, SOT25, SOT26, SOT89, SOT223,







Component Package - DIP

- Leaded Packages- Dual in line

Abbr	Description	Pins	Size LxW and Pitch
SOP	Small Outline Package	8 to 40 pins	5x4 to-16x8 mm; 0.4mm or higher
CSOP	Ceramic SOP		
SSOP	Shrink (skinny) SOP		
TSOP	Thin SOP		
TSSOP	Thin Skinny SOP		

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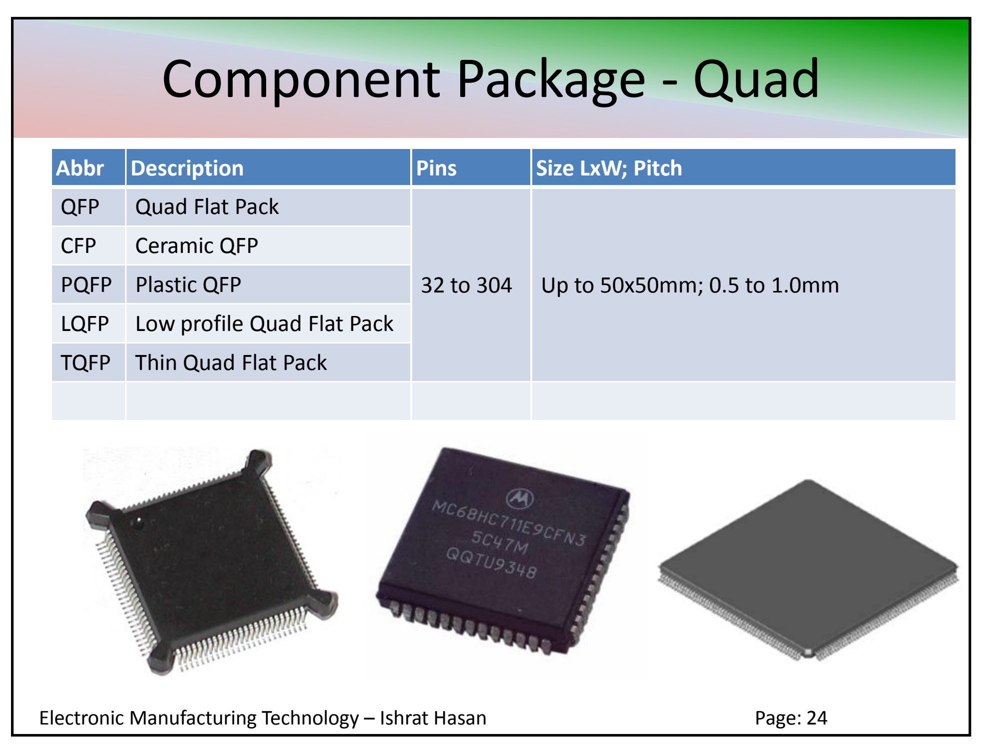

Component Package - Quad

Abbr	Description	Pins	Size LxW; Pitch
QFP	Quad Flat Pack	32 to 304	Up to 50x50mm; 0.5 to 1.0mm
CFP	Ceramic QFP		
PQFP	Plastic QFP		
LQFP	Low profile Quad Flat Pack		
TQFP	Thin Quad Flat Pack		

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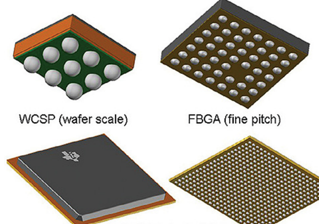
Component Package - BGA

- Ball Grid Arrays
- Benefits:
  - Better lead density and lead distribution on the chip
  - Easier to assemble and rework
  - Uniform ball shape reduces signal loss
- Sizes and pins
  - 4 Balls 1.0x1.0mm, 0.4mm pitch to 1800 balls and 1.0mm pitch



- Types
  - Plastic Ball Grid Array – PBGA
  - Ceramic Ball Grid Array – CBGA
  - Micro Ball Grid Array – µBGA
  - Thin Ball Grid Array -TBGA

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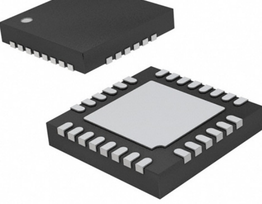
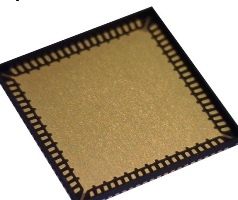
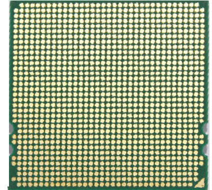
Component Package - LGA

- Leadless Packages
  - QFN
  - DFN
  - LGA
- Sizes and pitch
  - 2.0x2.0mm min and 0.4mm pitch
- Benefits:
  - Connects ground plane to the PCB for better heat dissipation and grounding
  - No signal loss in leads
  - Lower profile of the chip
  - Inaccessible pins improves security of the circuit







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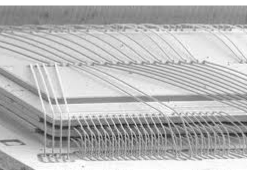
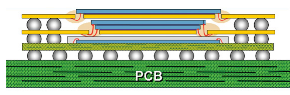
Component Package - Others

- 3 Dimension Packages
  - Multi chip module MCM (SIP or DIP)
    - Hybrid module
    - Specific application circuits pre-assembled and coated with molding compound
  - Stacked Chips
    - Multiple dies placed one over the other and wire bonded to the base substrate.
    - Packaged in a single module
  - Package on Package
    - Multiple packages stacked over





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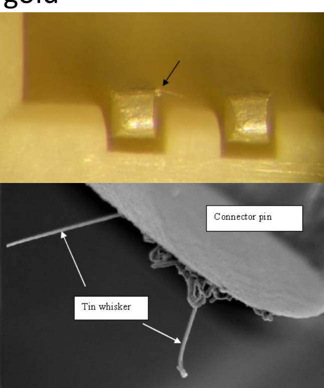
Component Package - Termination

- Component Lead Termination
  - Right coating on the lead improves soldering
  - Tin over Copper is the most common termination coating
  - Connector contact is coated with hard gold
  - Other options for lead coating are:
    - Silver
    - Leaded contacts Sn-Pb
    - Palladium mixed with other metals
  - Challenges with silver coating:
    - Tin Whiskers
    - Growth of tin crystals over time



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Printed Circuit Boards

PCB Surface Finish

- Gold
  - ENiG - Electro less Nickel and Gold. Soft gold for soldering
  - Electroplated Gold - Hardened Gold for contacts and wire bonding
- Immersion Tin
- Immersion Silver
- HASL - Hot Air Solder Level
  - Vertical HASL
  - Horizontal HASL
- OSP – Organic Surface Protectant

PCB Surface Comparison

	ENiG	Imm Sn	Imm Ag	OSP	HASL
Metals in the solder pad	Cu, Ni, Au	Cu, Sn	Cu, Ag	Cu	Cu, Sn, (Pb)
Layer thickness (micro inches)	Au 3-8 Ni 50-150	40-60	3-12	10-20	100-1000
Suitability to fine pitch lead	Excellent	Excellent	Excellent	Excellent	Poor
Solderability	Good	Good	Good	Concerns	Good
Solder joint reliability	Some concerns	Good	Good	Good	Excellent
Manufacturing issues	None	Oxidation	Oxidation	Rework concerns	None
Cost	2	1	1.5	0.5	1

Additional Information about PCBs

- Material Types
- RoHS and Non-RoHS
  - RoHS PCB should not contain
    - Lead
    - PBB and PBDE *(Polybrominated Biphenyls and Polybrominated Diphenyl Ether)* used as flame retardant in PCBs
    - Prepreg material should be able to maintain higher thermal glass temperature (**Tg**: 170°C) to support reflow at 250 °C

Flex Boards

- Benefits
  - Effective means to interconnect two boards
  - Can support complex box builds
- Flex only boards:
  - Typically less than 0.005”
  - Double sided mounting
  - Up to 4 layers
  - Surface finish: ENiG; HASL
- Rigid Flex
  - Combination of Rigid and Flex boards

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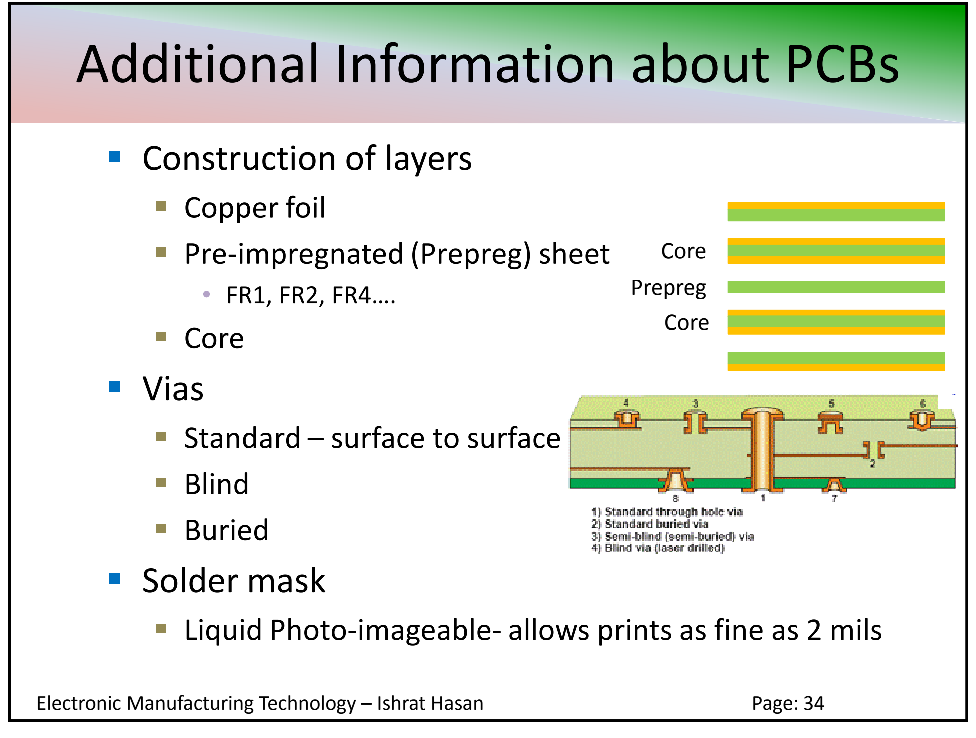

Additional Information about PCBs

- Design:
  - The PCB design should ensure balanced copper layer in each layer, i.e. traces should be routed to maintain uniform copper density across the layer and inter layer.
  - Choose the right copper thickness. Signal layer can be 0.5 or 0.25 oz. copper and ground planes can be 1 oz. or more

    1 oz. copper = 1.4 mil thickness
  - Thermal Relief
    - Connection of Conductor to mounting holes such that the excess copper would not drain heat during soldering

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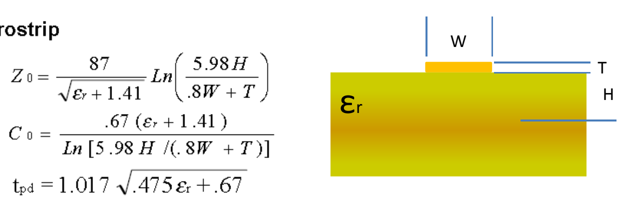
Additional Information about PCBs

- Trace Impedance
  - High frequency signal will experience signal loss for improperly designed traces
  - Typical trace impedance 50Ω for single trace and 100 Ω on the paired traces
  - The impedance, capacitance and propagation delay can be calculated for known PCB material permittivity, trace width, thickness and inter-layer distance



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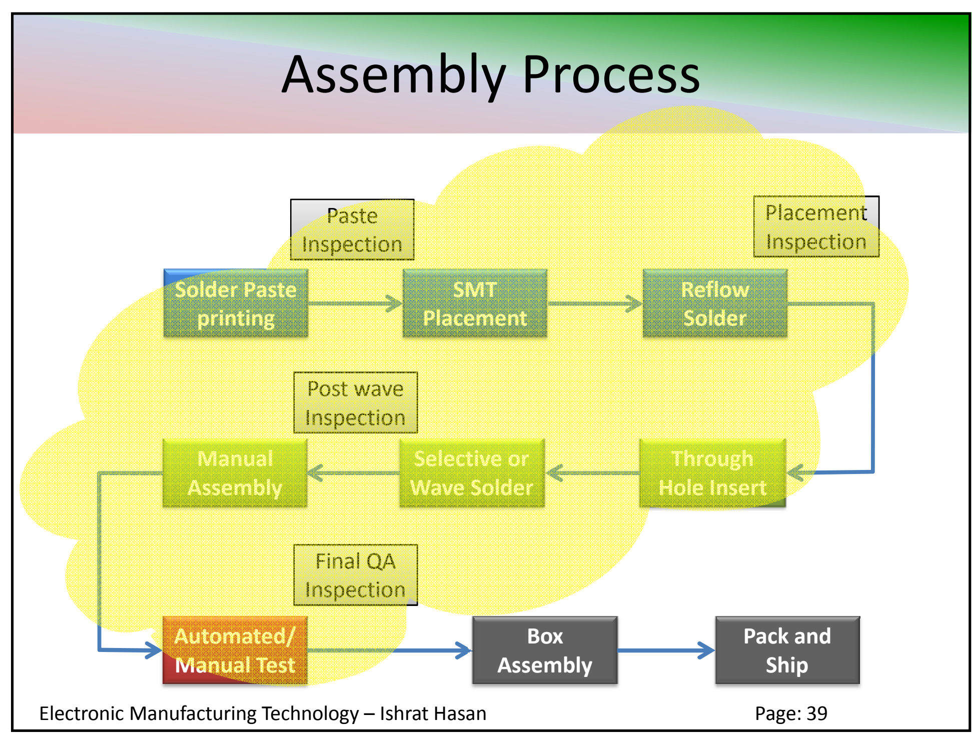
Additional Information about PCBs

- Most common PCB defects
  - De-lamination
  - Bowing and curving,
  - Solder mask peel-off etc.
  - Non-wetting of solderable surface
  -
- Refer to IPC standard IPC-A-600 for PCB specs.

Assembly Process and Equipment



Assembly Equipment

- Solder Paste Printing
- Placement Equipment
- Reflow Equipment
- Profiling
- Automated Optical Inspection Equipment
- X-ray
- Cleaning Equipment
- Paste Height Measurement
- BGA Rework Equipment
- Other Equipment
- Test Equipment

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Solder Paste Printing

- Key Materials:
  - Stencil Printer
    - Manual
    - Semi Automatic
    - Automatic
  - Stencil
    - Typical thickness 4-6 mils
    - Material: Nickel, Stainless Steel
    - Manufacturing process: Laser cut, Electroless forming
  - Solder Paste
    - Chemistry: No Clean or Organic Acid
    - Metallurgy: Leaded or Lead free
    - Powder sizes 3-5

Solder Paste Printers

- Types of Equipment:
  - Manual Printer
    - Manual alignment of stencil with the board
    - Manual operation of squeegee for printing of paste on the PCB
  - Semi Automatic Printer
    - Manual alignment of stencil with the board
    - Motorized operation of squeegee for printing of paste on the PCB
  - Automatic Printer
    - Camera assisted alignment of PCB to the stencil
    - Motorized operation of squeegee for printing of paste on the PCB
    - Under stencil wiper for cleaning of solder paste residue

Solder Paste Printers

- Other solder paste printing techniques
  - Solder paste dispensing
    - Pneumatically controlled solder paste deposited at specified locations based on CAD data
    - Used for high volume deposits, e.g. RF shields, bulky parts,
  - Solder paste jet printing
    - Similar to ink jet printer, paste printed on the PCB using a high speed printer head. Typical 500 dots/sec
  - Benefits of jet printing:
    - No stencil required. Highly flexible. Easy to manage changes
  - Disadvantages
    - Does not support high volume manufacturing
    - New technology, still in infancy stages

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Stencil

- Key variables
  - Material:
    - Mesh screen
    - Metal Foil
      - Stainless Steel, Nickel
  - Apertures:
    - Laser cut
  - Aperture finish:
    - Electro-polish for smooth wall
    - Chemically treated
  - Electroless E-form
    - Deposit of material to achieve specific thickness and smooth finish

Stencil

- Sizes
  - Stainless steel foil common sizes 4-6 mils
  - Glue printing stencil can be 6-8 mils thick
  - E-form stencils can be made in other thicknesses
  - Frame size
    - 20x20” Thickness ½” or 1”
    - 29x29” Thickness 1-1/2”

Stencil Design

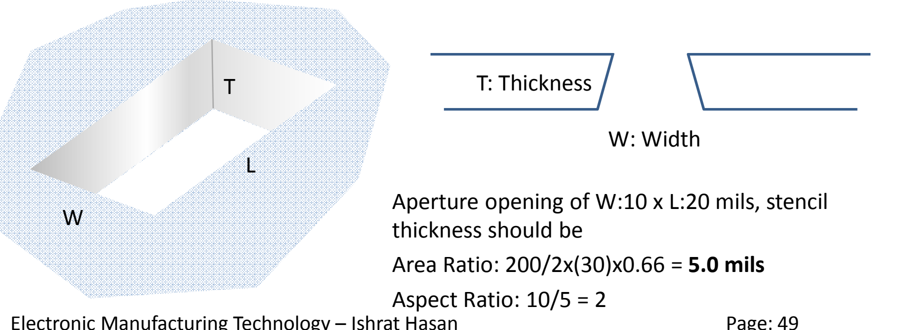
- Driven from the PCB CAD data using the paste layer
- Aperture reduction
  - Improves registration with the PCB
  - Reduces solder balling, excessive paste and other printing defects
  - General reduction 5-15% by area, concentric
  - Shape adjustment – home plate, window pane
  - No sharp corners to improve paste release
  - Aspect ratio = 1:1.5
  - Area ratio = 0.66 or 0.5 (eForm)

Stencil Design

- Examples of aperture reduction

Stencil Design

- Aspect Ratio and Area Ratio are important for optimum release of paste from the stencil
  - Aspect Ratio= Width/Thickness >1.5
  - Area ratio: Area of aperture/Area of wall > 0.66
  - Aperture opening area/Aperture wall area: [L x W]/[2(L+W)x T] > 0.66



Aperture opening of W:10 x L:20 mils, stencil thickness should be

Area Ratio: 200/2x(30)x0.66 = **5.0 mils**

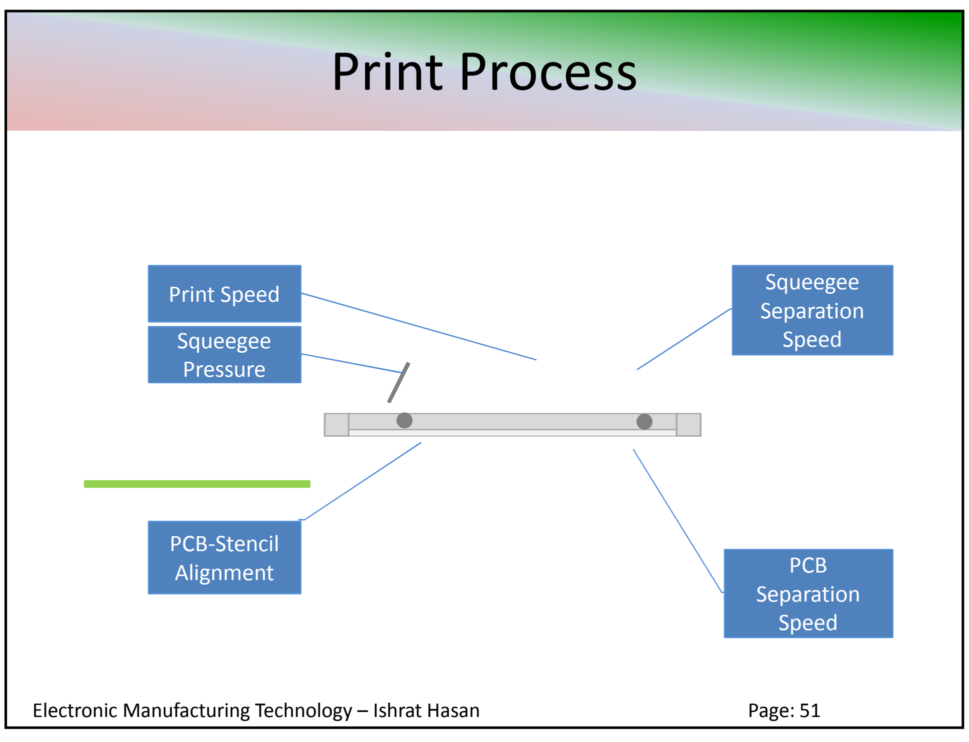
Aspect Ratio: 10/5 = 2

Other Techniques

- Step stencil
  - Purpose is to have a thicker layer of solder paste in certain specific locations for additional paste
  - E-form or etch base material to create step on print side
  - Typical step sizes < 3mils
  - Printing on step stencil close to step areas is a challenge

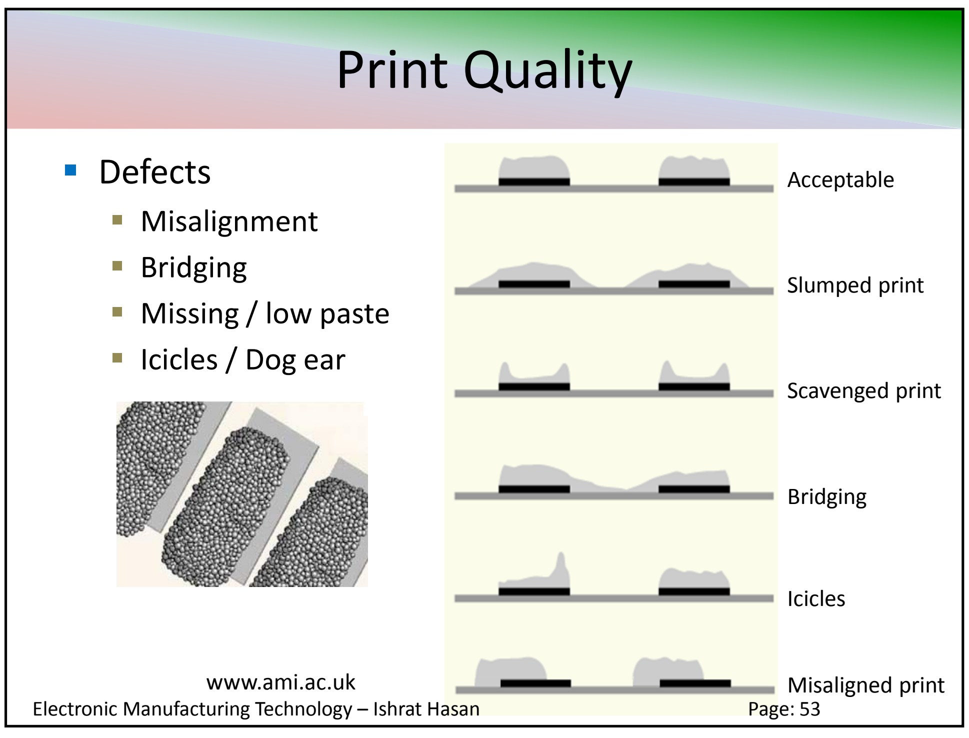
- Under-side cavity
  - Opposite of step, cavity created on the PCB contact side to accommodate dual material

Standard thickness Step Under side cavity



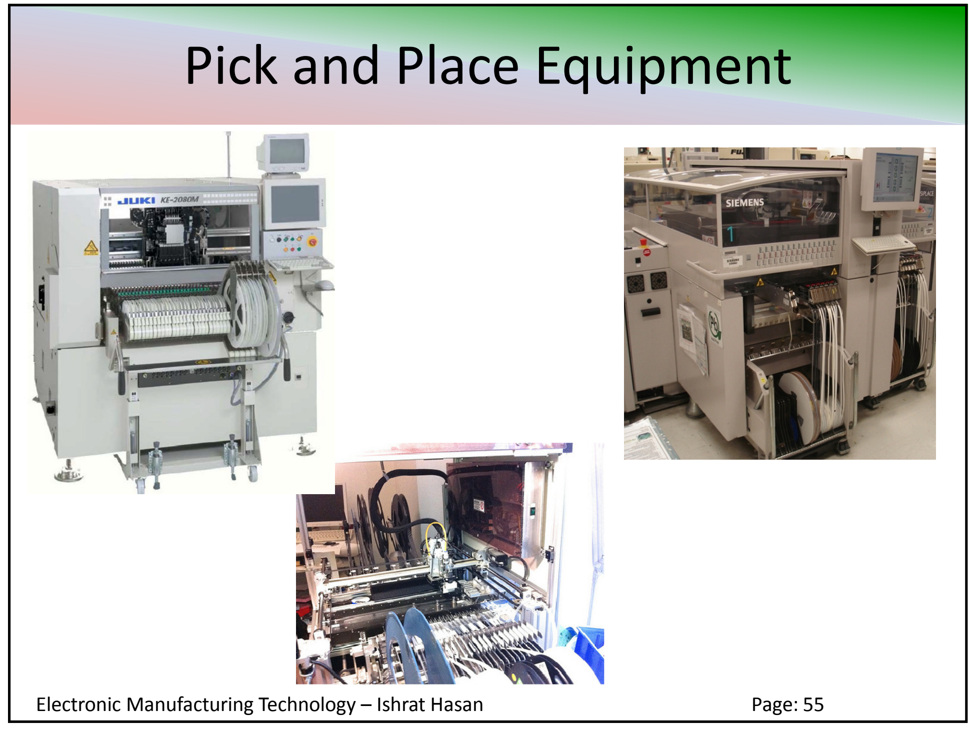
Print Parameters

- Printer parameters
  - Alignment of board to stencil
  - Speed of squeegee
  - Squeegee pressure
  - Print direction
  - Separation speed of squeegee
  - Separation speed of stencil
  - Cleaning of under-side of stencil (frequency and wet/dry)
    - Challenges with more frequent cleaning
    - Cleaning liquid



Pick and Place Equipment

- Leading manufacturers
- Construction of Pick and Place machine
- Operation of Pick and Place machine
- Key features and parameters of the P&P machine
- Types of machines and construction
- Feeders
- Package Library



Pick and Place Equipment

- Leading Manufacturers
  - Panasonic
  - Assembleon (formerly Philips)
  - ASM (formerly Siemens)
  - Fuji
  - Universal
  - Hitachi
  - Juki
  - My data
  - Europlacer

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Pick and Place Equipment

Construction of the placement equipment

- Conveyor to transport the boards in and out of the machine
- Feeder bank table and feeders to hold the components and to be presented to the head for placement
- Vacuum nozzle(s) installed on a head which is precisely controlled in x/y/z/θ directions to pick and place the parts
- The head can pick a part through vacuum and place it at a precise location
- Vision system in the head can verify the part size and number of pins before placement
  - Verifies pin count, size and bent pin/missing ball defect

Pick and Place Equipment

Construction

Feeders

Head

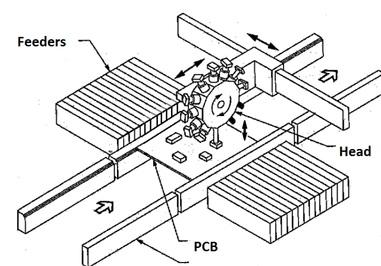
PCB

Conveyor

Pick and Place Equipment

Machine types by construction

- Gantry
  - Head moves in x,y,z, and θ directions. Feeders are stationary
- Split Axis
  - Head moves in x,y and θ direction, PCB moves in z direction. Feeders are stationary
- Fixed Turret
  - Head location is fixed, feeder moves to pick up point and PCB moves to the same point for placement



Pick and Place Equipment

- Machine types by function
- Chip Shooter
  - High throughput machine
  - Capable of speeds of over 100,000 CPH
  - Component size is limited, usually < 32mm
  - Used for mostly non fine pitch parts
- Fine pitch placer
  - Throughput is relatively slow
  - Capable of placing parts with fine pitch leads
  - Limited number of nozzles on the head
  - Can place large size parts and odd shaped parts

Pick and Place Equipment

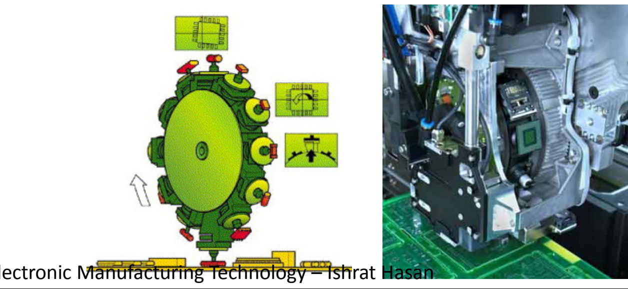
- Placement Heads

  Rotary Head
  - Rotary wheel with number of nozzles (4-20 nozzles) and each one capable of pick and place parts and z and θ movement
  - Used for small components only, limit 32 mm size
  - Placement speed: very high (20-40 kCPH)

  In line head
  - Linear nozzles
  - Can do simultaneous pick up
  - Can manage larger size components, 50mm or longer
  - Placement speed: comparatively slow

Pick and Place Equipment

- Parts of Placement Head
  - Nozzles
  - Vacuum system
  - Z and θ controls
  - Fiducial camera

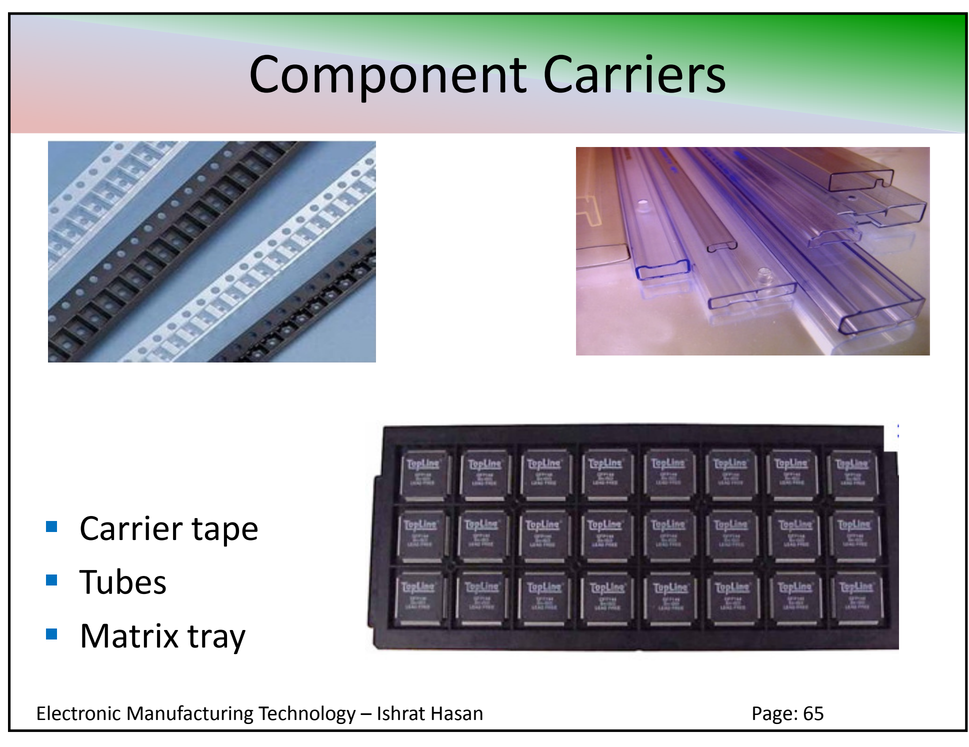


Pick and Place Equipment

- Vision System
  - PCB alignment camera installed in the head
    - Used for indexing the PCB to determine the x,y location reference to the head
  - Component camera installed at a fixed location
    - Used for verifying component size and leads
  - The components are verified per the component package library

Pick and Place Equipment

- Feeders
  - Carrier for the components for presenting the component to the head for placement
- Feeder Types
  - Tape feeder
  - Matrix Tray feeder
  - Tube feeder
  - Bulk feeder
  - Label feeder
- Feeder Sizes:
  - Based on the width of the tape and pitch of movement
  - Typical sizes 8, 12, 16, 24, 32, 44, 56, 72, 84mm
  - Pitch options available


Component Carriers
Carrier tape
Tubes
Matrix tray
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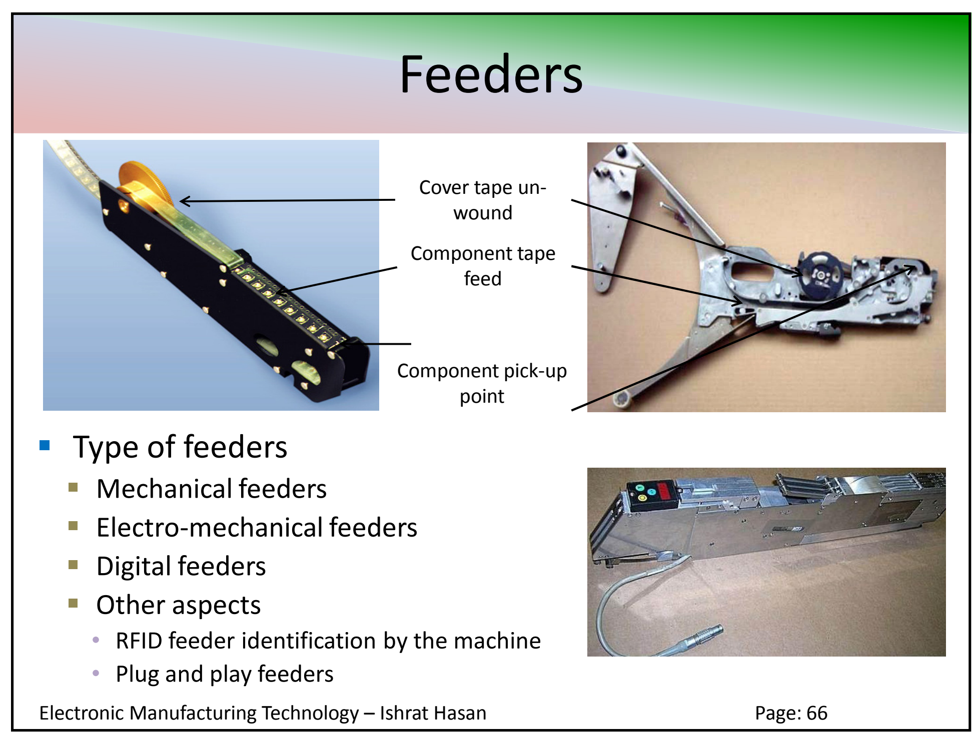
Feeders
Cover tape un-wound
Component tape feed
Component pick-up point
Type of feeders
Mechanical feeders
Electro-mechanical feeders
Digital feeders
Other aspects
RFID feeder identification by the machine
Plug and play feeders
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Feeders

Matrix tray feeder front and rear view

Pick and Place Equipment

- Operation of placement equipment
  - Board moves over the conveyor to the board stop location
  - Camera positions and index the board through fiducial
  - Head moves to the feeder to pick the part
  - Picked component is presented to the camera for verification
  - Component positioned over the location of placement
  - Head moves down to place the part
  - Remaining components placed
  - Board moves out of the machine to next step

Pick and Place Equipment

- Capacity and Capability
- Placement Accuracy
- Placement Speed
- Examples

Pick and Place Equipment

- Capacity and capability
  - For a complete SMT line, capacity and capability depends on:
  - Number of heads in the machine
  - Type of components it can handle for placement
  - Largest size of component the head can place
  - Number of feeder the machine can handle. This also determines the number of different type of components for a product set up.
  - Board size, conveyor opening and extent of the movement of head

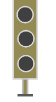
Pick and Place Equipment

- Features
- Placement Accuracy
  - Resolution:
  - Measure of the smallest x, y, z and θ step of the machine
  - Determines the placement precision of the machines
  - Typical placement accuracy of machines: ± 40 μm, 0.1°

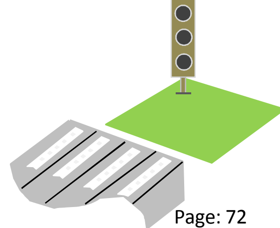
  - Repeatability:
  - Minimum deviation from the specs
  - Defines in sigma level: Typical deviation 3-4 sigma

Pick and Place Equipment

- Placement speed
  - Placement rate of the P&P Head: CPH (components per hour)
  - Manufacturer specifications usually defines the head speed
  - IPC standard IPC 9850: for comparison of different machines
    - On a standard board for specific type and quantity of components
    - Measures speed and defect in DPMO
  - Speed de-rating factors:
    - Board transfer, feeder location, type of components



Feeder Board



Pick and Place Equipment

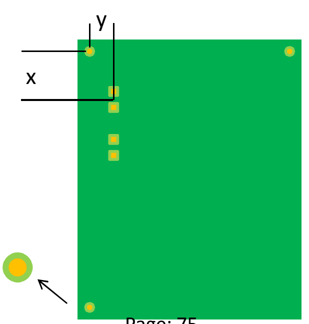
- What is de-rating
  - If a machine is rated at 20,000 CPH and a single-sided board is on the line which has 250 parts on the board. How many boards will be produced in an hour?
  - Boards/hr. = 20,000/250 = 80
  - 80 is based on theoretical speed of the head or IPC rating.
  - Time is wasted in
    - Board transfer in and out of the machine
    - Vision system
    - Slow down of head due to large components
    - Head travel to different feeders
  - With de-rating factors, actual expected boards/hr. = **40**

Pick and Place Equipment

- External de-rating factors
  - Changeovers
    - As a product is removed from the machine and new set up created, it takes 20-60 minutes for set up depending on the type of product.
  - Program debugging
    - Minor edits may be required for adjusting changes in parts, PCB or general feeder conditions
  - First Article Inspection (FAI) time
    - Every first board should be verified before the entire batch is processed
  - Replenishment of components in the feeders
    - As the parts run out in the feeder the reels have to replenished and it may cause the machine waiting.

Programming

- Input to the machine program:
- CAD data exported from PCB files to machine format
  - Data contents:
    - Fiducial location on the board
    - X and y location of each component's centroid location
    - Θ rotation of each component
    - Component identifier or part number
    - Reference designator
- Bill of material
    - Reference designator
    - Part number
    - Part description



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Programming

- Program creation:
  - Package library
    - Most of the packages are supplied with the machine
    - Key parameters of the parts in package library:
      - Component body size x and y
      - Outer size including leads,
      - Pin count, size of pins
      - Thickness
      - Pin 1 reference
      - Optimum light level to be best identify the reflection of the part
      - Nozzle assignment to pick the part

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Programming

- Programming process:
  - Assign a package to each part in the program
  - Determine the packaging type, tape, tray or tube
  - Determine the packaging size, tape width and step, matrix tray dimension
  - Optimize the program for most efficient location of the feeders in the feeder table
  - Create the trolley loading scheme
    - Location of feeders, orientation of parts

Examples

- A PCB with the following specs:
  - Double sided
  - 200 items in the Bill of Material
  - Type of parts: Chip components, SOIC, QFP/BGA, connectors
- What is the most suitable configuration of the machine?
  - Total 8mm equivalent feeders require: 320 + 20 trays
  - Each machine has 120 feeder capacity for 8mm feeders and 28 trays in tray feeder
  - **Machine configuration:**
    - **2 chip shooters= 240 feeder slots**
    - **1 Fine Pitch Placer= 90 slots + 28 trays**

Example

- 1500 boards with the following specs. have to be produced every day. What is the suitable configuration of the pick and place machine?
- Board specs:
  - Single sided
  - 65 items in the Bill of Material, 250 placements
  - Type of parts: Chip components, SOIC, QFP/BGA, connectors
- Machine configuration
  - Chip shooter: 30,000 CPH
  - FP Placer: 18000 CPH

Example

- Cycle time
  - CS: 30,000 CPH; 160 placements: 21 sec (bottleneck machine)
  - FP Placer: 18,000 CPH, 90 placements: 18 sec
  - Cycle time through the line: 21 sec
  - Machine throughput: 3 board/min
  - Or 1620 boards/ day in 9 hour shift
- Other factors to consider:
  - Printing speed
  - Reflow speed

Reflow Soldering

- Types of reflow soldering and reflow ovens
  - Hot plate convection reflow
  - Infra red conduction reflow
  - Vapour phase reflow

Reflow Soldering

- Construction
  - Individually controlled heat zones
  - Speed controlled conveyor
  - Air circulation system
  - Nitrogen atmosphere (optional)
    - Why Nitrogen
      - Reduces oxygen from the soldering environment
      - Improves wetting of solder
      - Produces shiny solder joint
  - Commonly ovens today are 8-10 hear zones and 2-3 cooling zones

Reflow Soldering

- Leading manufacturers
  - Vitronics
  - Conceptronic
  - Heller
  - Electrovert
  - BTU

Reflow Soldering

- Reflow profile
  - The temperature and belt speed setting that will provide the correct time and temperature relationship for heating and cooling the assemblies
  - Controlling parameters for the profile are:
    - Solder paste specifications (flux and metal)
    - PCB material specification
    - Components soldering guideline

Reflow Soldering

- Stages of soldering
  - Pre-heat
    - 1-2°C/sec up to 125°C
  - Soak
    - Activate the flux – 60 to 120 sec up to 170 °C
  - Liquidous stage
    - 2-3°C/sec up to 230 or 250°C [Pb or Pb free]; 50-70 sec
  - Cool down
    - 2-4°C up to 150°C
  - Temperature delta on the board < 15°C all the time

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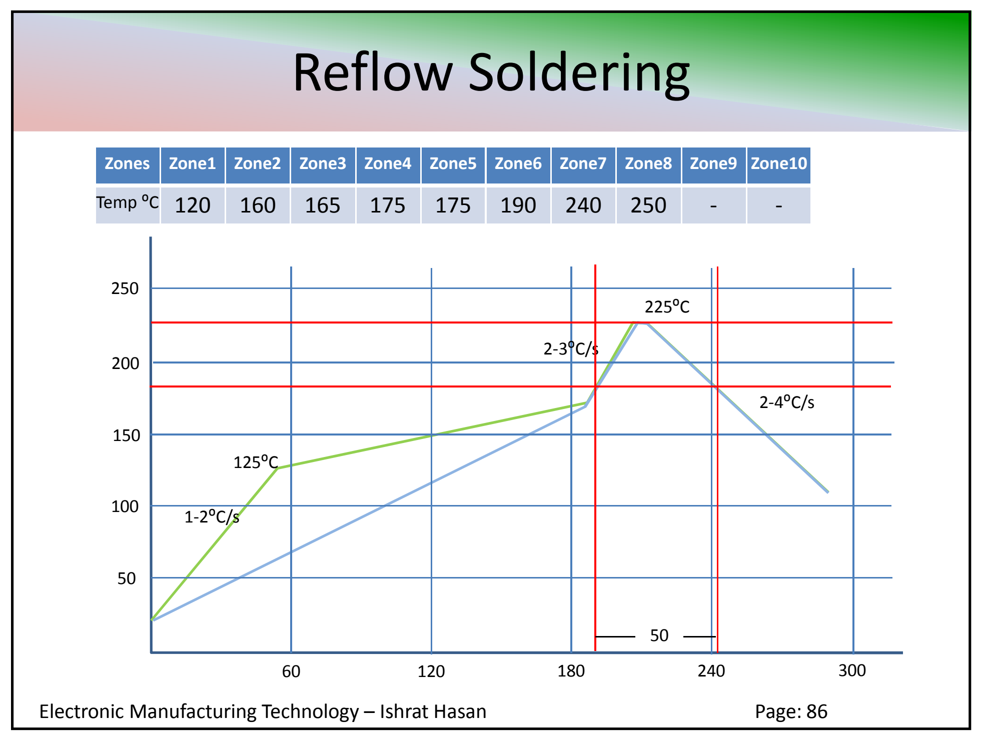
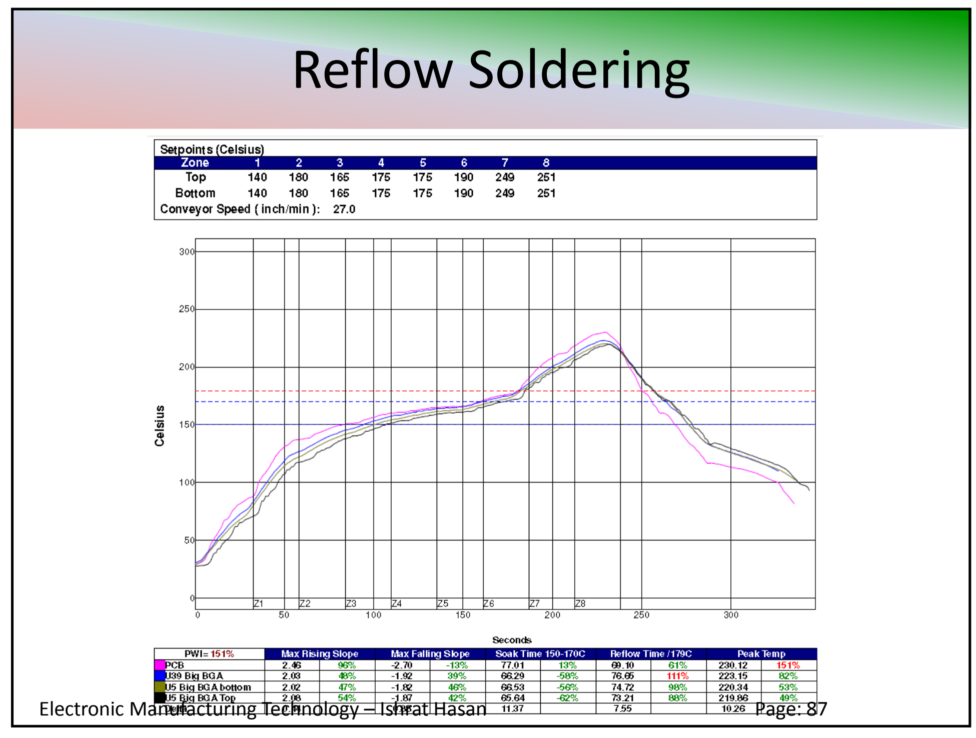


Zones	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6	Zone7	Zone8	Zone9	Zone10
Temp °C	120	160	165	175	175	190	240	250	-	-



Reflow Soldering

Setpoints (Celsius)

Zone	1	2	3	4	5	6	7	8
Top	140	180	165	175	175	190	249	251
Bottom	140	180	165	175	175	190	249	251

Conveyor Speed (inch/min): 27.0

PWI= 151%	Max Rising Slope		Max Falling Slope		Soak Time 150-170C		Reflow Time /179C		Peak Temp	
PCB	2.46	96%	-2.70	-13%	77.01	13%	69.10	61%	230.12	151%
U39 Big BGA	2.03	48%	-1.92	39%	66.29	-58%	76.65	111%	223.15	82%
U5 Big BGA bottom	2.02	47%	-1.82	46%	66.53	-56%	74.72	98%	220.34	53%
U5 Big BGA Top	2.08	54%	-1.87	42%	65.64	-62%	73.21	88%	219.86	49%
Delta	[illegible]		[illegible]		11.37		7.55		10.26	

Profiling Procedure

- Profiler:
  - Temperature recording device
  - Can read simultaneously from up to 9 thermocouples
  - Stores temperature at 1 sec intervals
  - On downloading in computer, the profile graph is created
  - Software can suggest adjustment in zone temperature to achieve target conditions

Automated Optical Inspection

- AOI: Automated Inspection Equipment
- Can be used for:
  - Mostly common for SMT inspection but can be used for TH inspection with some limitations
  - Post reflow inspection – Most common
  - Post placement inspection
  - Post solder print inspection

Automated Optical Inspection

- How the equipment works
  - Equipment has a conveyor to move the board in the machine at an index position
  - A camera moves on a x, y gantry and takes images of board in small 1.5" x 1.5" blocks
  - All the images are combined in a single image through machine software
  - The programmer review all the images and cleans out the anomalies
  - This first board becomes the golden board or the program
  - Subsequent boards are scanned and images compared with programmed images and decision taken for acceptance or otherwise.

Automated Optical Inspection

- AOI capabilities, can identify:
  - Missing parts
  - Wrong polarity
  - Part marking
  - Solder joint opens except BGA, LGA
  - Solder joint bridging except BGA, LGA
  - Can read and identify colors from the resistor color bars
  - Can read vales on the side of the parts using the side camera

Automated Optical Inspection

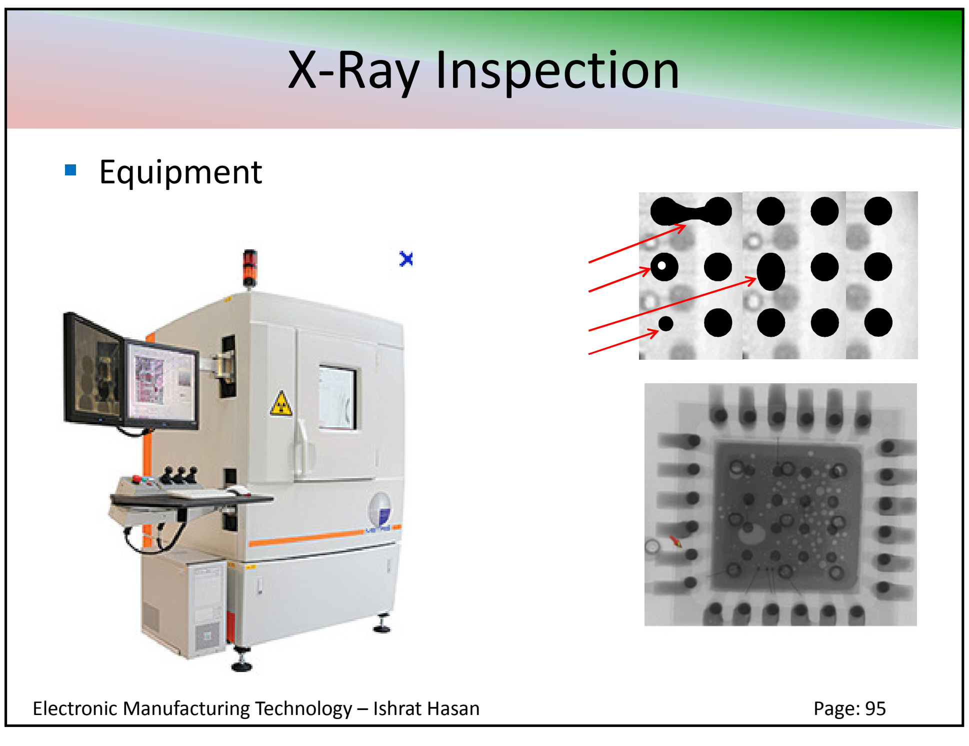
- Challenges with AOI
  - Each image comparison is not perfect
  - Original saved image and scanned image may have color mismatch
  - Font mismatch on marking
  - Shifted images
  - All these anomalies cause False Calls which operator has to review manually and clear out
  - Solution:
  - Save multiple images as alternate for each part

Automated Optical Inspection

- AOI Throughput
  - A typical AOI machine can scan an average 6”x8” board in less than a minute per side
  - Depending on the calls (defect or False calls) an operator can review the board in less than 2 minutes
- Inspection Statistics
  - False Calls Rate: Number of Calls/No of opportunities
  - Typical FC < 1%
  - On a board with 2500 opportunities, typical FC < 25

X-Ray Inspection

- BGA/LGA/QFN inspection using X-ray machine
  - Used for inspecting hidden solder joint
  - X-ray image can clearly show the defects such as:
    - Solder bridge
    - Voids in solder joint
    - Missing solder
    - Excessive solder
    - Possibly incomplete reflow
  - Cannot identify:
    - Cracks in solder joint



Cleaning Equipment

- In line Cleaner
  - Conveyor carries the boards in a tunnel with top and bottom sprays
  - May have up to 5 spray zones
  - DI water used – Reduces the surface tension
  - Chemical (saponifier) used to clean hard chemicals such as the No Clean fluxes
  - Drying section at the end
  - Closed loop system to minimize the use of water

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Paste Height Measurement

- Laser paste height measurement
  - Measures the height of the printed solder paste using a laser beam
  - Records the reading
  - All the saved readings are averaged to view the trend
  - Helps in maintaining control of print parameters

BGA Rework

- BGA Rework
  - Ability to remove and place components on a board
  - Ability to align parts using a split prism looking upwards on the pins and downwards on the pad
  - Ability to create the right temperature profile for soldering
  - Vacuum assisted removal and placement of parts

Other Equipment

- Automated Loaders and Un-loaders
- Conveyors
- Board Flipper
- Retractable conveyor
- Stencil Cleaner
- Batch Cleaner
- 3D X-ray Laminography and Tomosysthesis Imaging

Test Equipment

- In-Circuit Tester
  - Bed of nails top and bottom of the board
  - Parallel access of all test points
  - Suitable for high volume testing
  - Custom fixture required for each board - $$$
- Flying Probe Tester
  - Board placed at a fixed location
  - Test head moves to each test point to inject and retrieve a signal
  - No fixture required
- Manufacturing Defect Analyzer
  - High speed testing
  - Combines on-chip test capabilities (Boundary scan) with ATE speed
- Boundary Scan
  - On chip test capability
- Functional Test
  - Custom test set up for a board.
  - Highly flexible and accurate but generally slow

Test Equipment

- Hi-Pot test
  - High voltage insulation and leakage test
- Environmental Test
  - HALT
  - HASS
  - Vibration test
  - Shock test
  - Drop test
  - Thermal and humidity cycling

Assembly Materials

Solder Paste

- Composition and classification
  - Metallurgy
    - Sn Pb 63 - 37
    - Sn Pb Ag 62 - 36 - 02
    - Sn Ag Cu (SAC) 96.5 - 3 - 0.5 or 95.5 - 3.8 - 0.7
    - Powder size

#	Max particle size (µm)	Particle size range (µm)
1	150	150-75
2	75	75-45
3	**45**	**45-25**
4	38	38-20
5	25	25-10
6	15	15-5

  - Chemistry
    - No Clean
    - Water soluble OA

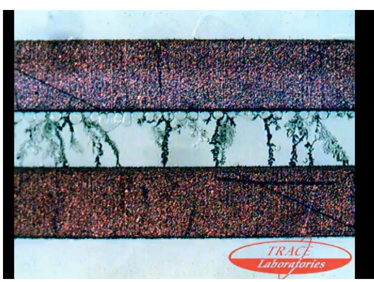
Solder Paste

- Physical features
  - Easy to print: Viscosity, Thixotropy, Powder size
  - Print release: Viscosity, Thixotropy, Rheology
  - Print fill: Viscosity, Thixotropy
  - Stay in place (slump): Viscosity
  - Hold components: Tackiness
  - Residue: General chemistry
  - Cleaning ability: General chemistry

Solder Paste

- Solder Paste Chemistry Functionality
  - Creates the solder joint
  - Cleans and remove oxidation from the surface for good solder joint
  - Promotes wetting of solder on the pad surface
  - Cleanable
  - Non-conductive residue
  - Does not cause dendroid growth

http://www.youtube.com/watch?v=uyO-XE-Q9ZQ



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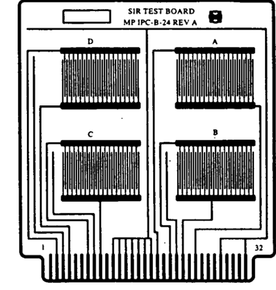
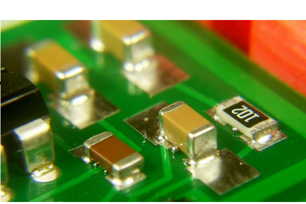
Solder Paste Test

- Post reflow cleanliness test
  - To verify that the ionic contamination on the board are within limit. Conducted in an Ionograph in Alcohol solution. Acceptable limit is 10µgm/Sq.
  - SIR coupon is used as a standard specimen



- Solder balling test
  - Place a small quantity of solder paste on the solder mask on a board and reflow it. Observe the solder ball formation



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Solder Paste

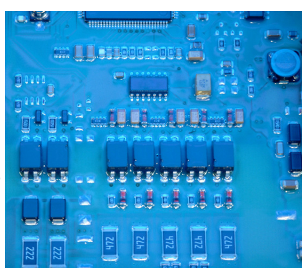
- Other factors to be controlled in solder paste
  - Shelf life
  - Stencil life
  - Wide range of temperature and humidity adaptability
  - Low solder balls
  - Clear residue
  - Test pin penetration

Conformal Coating

- Purpose:
  - A chemical coating applied on the board surface to protect it from moisture attack, electrical discharge and security
  - Uses:
    - Boards harsh environments in industry, outdoors or military
  - Types:
    - AR – Acrylic
    - ER – Epoxy
    - SR – Silicone
    - UR – Polyurethane
    - XY – Paraxylene

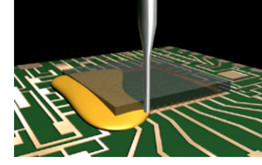
Conformal Coating

- Application methods
  - All but Parylene can be sprayed, brushed or dipped
  - Cures in less than an hour for handling
  - Full cure in 24 hours
  - Can be cured under UV light, heat or air circulation
  - Typical thickness as per IPC: 1-5 mils, silicon could be thicker
- Defects could be:
  - Insufficient thickness
  - Orange peel effect
  - Non-adhesion and peel off from surface
- Inspection under Black light

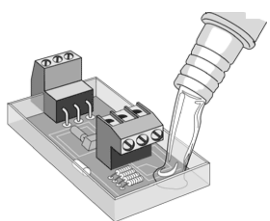


Conformal Coating

- Other similar materials
- Under-fill
  - Commonly used for securing BGAs on a board or Flip Chip in an IC package
  - Purpose: balance the CTE mismatch of the die and board during thermal expansion and avoid solder crack



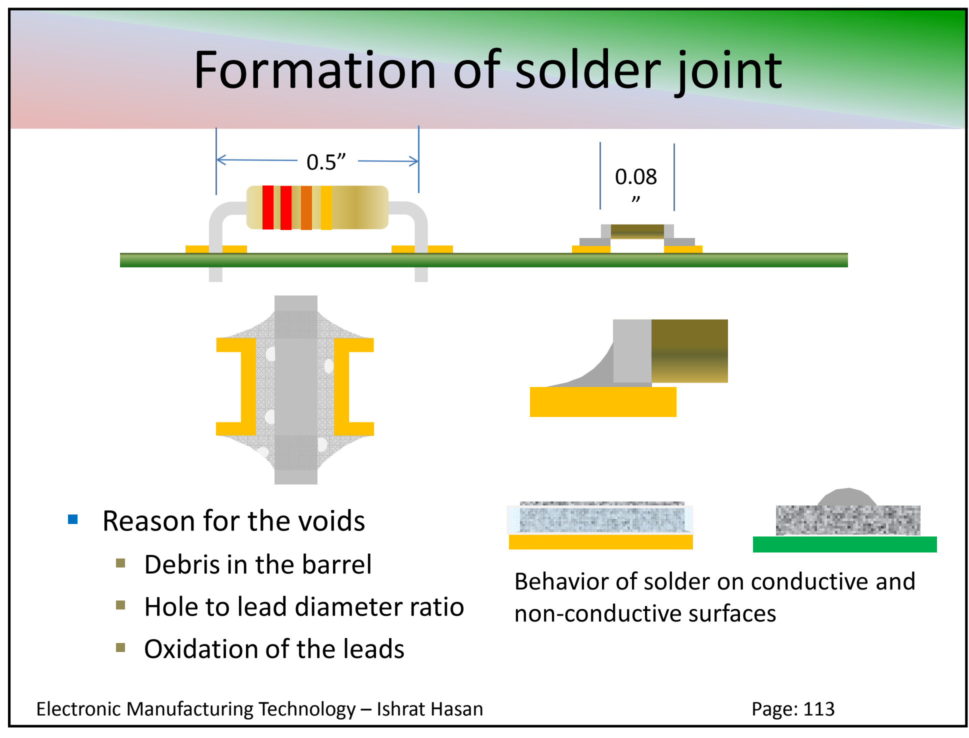
- Potting compound:
  - A two or three parts epoxy used to encapsulate an assembly as a solid block.
  - Used for extreme protection against shock and vibration
  - If failed, the assembly is generally not repairable



Solder Wire

- Materials:
  - Metallurgy: RoHS – SN100C, SAC 305, Others
  - Non-RoHS – Sn-Pb 63-37, Sn-Pb-Ag 62 36 02
  - Core: No Clean or OA
  - No Clean flux types: R0L0, R1L1… Determines activity level of the flux
- Diameter
  - Wire di should be chosen to suit the pitch of the pins being soldered
  - Reduce post soldering activity levels by curing the flux at 100C for 5-10 sec

Soldering


Formation of solder joint
0.5”
0.08 ”
Reason for the voids
Debris in the barrel
Hole to lead diameter ratio
Oxidation of the leads
Behavior of solder on conductive and non-conductive surfaces
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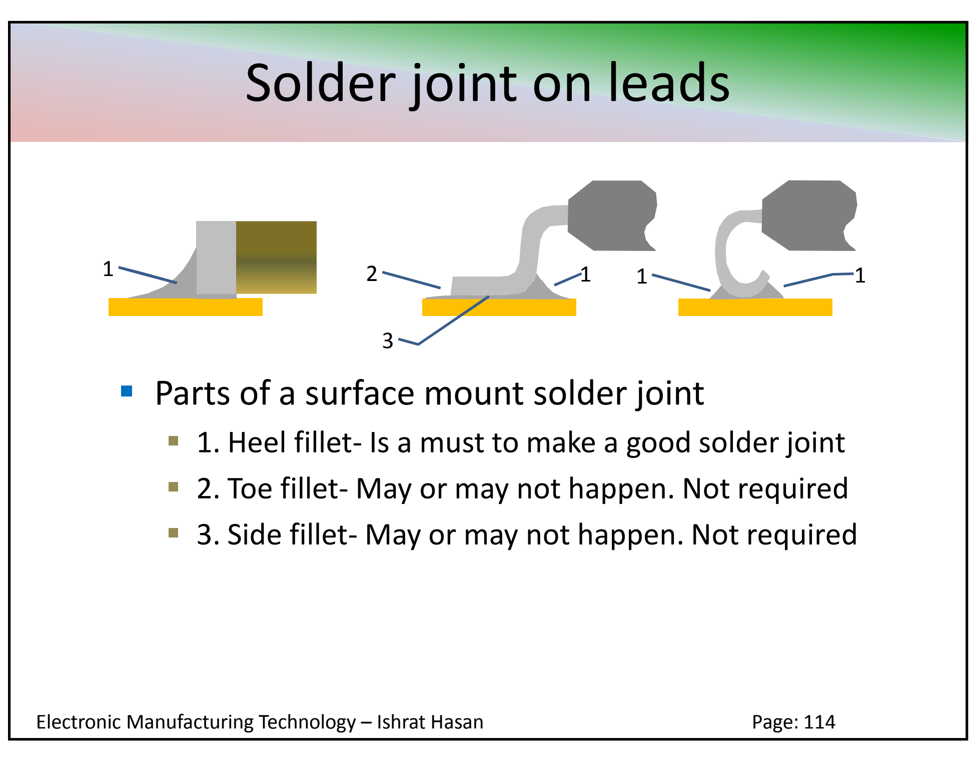
Solder joint on leads
1
2
1
3
1
1
Parts of a surface mount solder joint
1. Heel fillet- Is a must to make a good solder joint
2. Toe fillet- May or may not happen. Not required
3. Side fillet- May or may not happen. Not required
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Intermetallic in Solder Joint

- Metals in a compound migrate within the compound when in molten state
- This migration continues until all metal is depleted
- For bonding of two metals the migration should be controlled to achieve optimum wetting of the metal with other metals.
- This optimum bonding is intermetallic
- In solder joint formed with Tin and lead solder, intermetallic determines the strength of the solder joint
- Right amount of tin is required to make a strong solder joint
- Excessive tin depletion will leave too much lead in the intermetallic causing weak and brittle solder joint
- Intermetallic layer is controlled by the time and temperature of the solder when it is in molten state

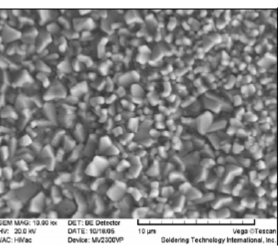
Intermetallic in solder joint

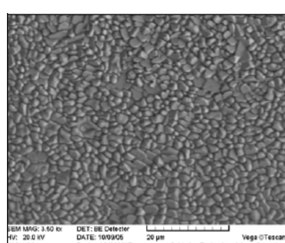
- Intermetallic is needed to form a solder joint
- Intermetallic promotes wetting which is required for bonding and creating a solder joint
- Good wetting between two surfaces is determined based on the amount of intermetallic
- The intermetallic thickness in Cu-Sn is typically 1.0 to 2.5 microns
- Less than this thickness means non-wetting condition
- Thicker layer of intermetallic leads to brittle solder joint
- One of the common reasons for thicker intermetallic is prolonged soldering

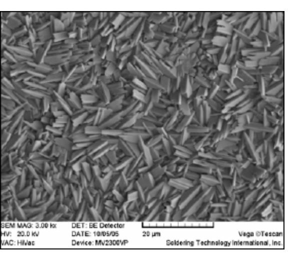
Take away

- A solder joint is best formed by using a good flux and controlled heat.
  - Flux is a soldering re-agent which cleans and de-oxide the surface being soldered and promotes wetting
  - Correct temperature ensures that the solder melts for the right amount of time and spreads over the soldering surface and cools down under control
  - Over temperature, prolonged heating and repeated heating of the same joint changes inter-metallic layer thickness and weakens the solder joint
  - These solder joints can fail under mechanical or thermal stress causing the assembly to fail

Intermetallic in solder joint


Sn-Ni intermetallic


Cu_3Sn intermetallic


Cu_6Sn_5 intermetallic

- Intermetallic is a crystalline structure
- It is generally brittle in nature
- It is easy to for a crack to propagate through intermetallic
- Mechanical vibration and abrupt thermal shocks causes fracture in the solder joint causing failure

Intermetallic in solder joint

- Most common intermetallic in the solder joint are:
- Sn-Cu Tin copper intermetallic when soldering on copper
  - Intermetallics are formed in two phases
    - Cu_3Sn near the copper layer
    - Cu_6Sn_5 above the first layer
- Ni-Sn intermetallic when soldering on ENiG boards
  - Intermetallic are formed in three layers
    - Ni_3Sn_4 layer is added
    - Gold is removed from the surface and moves on the surface of the solder joint
    - Solder joint on gold surface appears a little dull compared to HASL solder joint due to presence of gold
    - High application circuits do not prefer gold surface boards as gold causes the solder joint to become brittle

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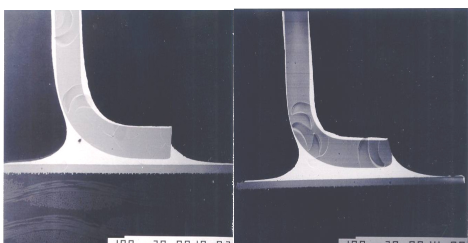
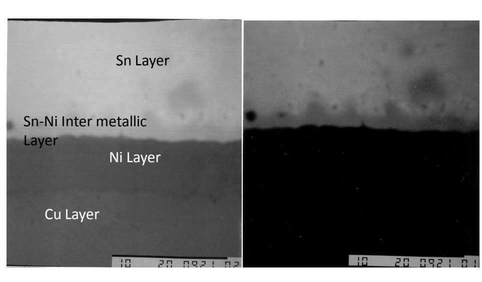
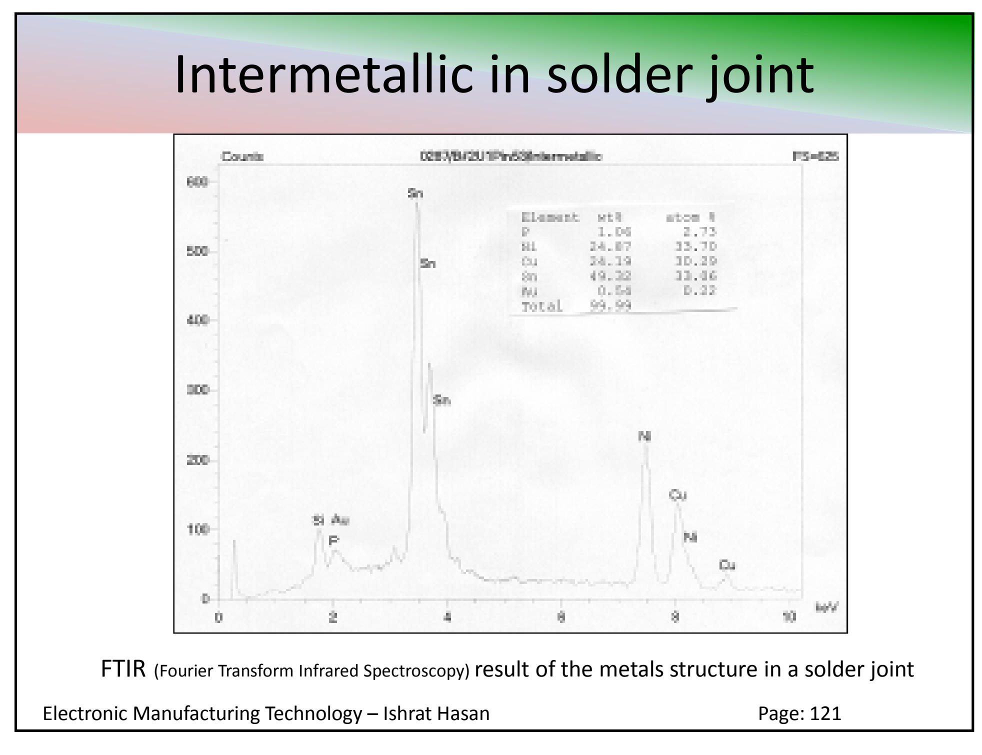
Intermetallic in solder joint



Example of Lead free solder joint on a QFP lead. High magnification shows the Cu, Ni and Sn layers with Sn-Ni intermetallic



Electronic Manufacturing Technology – Ishrat Hasan Page: 120


Intermetallic in solder joint
Counts
Sn
Sn
Sn
Ni
Cu
Ni
Cu
Si Au
P
Element wt% atom %
P 1.06 2.73
Ni 24.87 33.70
Cu 24.19 30.29
Sn 49.32 33.06
Au 0.56 0.22
Total 99.99
keV
FTIR (Fourier Transform Infrared Spectroscopy) result of the metals structure in a solder joint
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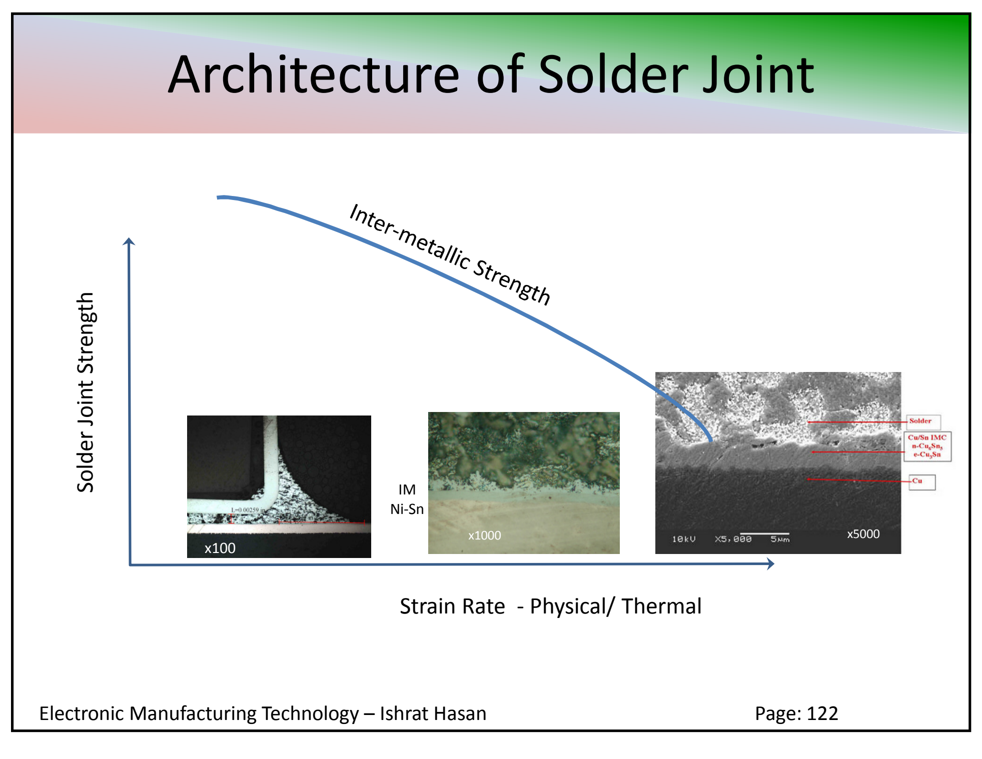
Page: 121


Architecture of Solder Joint
Inter-metallic Strength
Solder Joint Strength
IM
Ni-Sn
x100
x1000
x5000
Strain Rate - Physical/ Thermal
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Agenda

1. Electronic Manufacturing
2. Manufacturing Technology
   - Electronic Components
   - Assembly Equipment
   - Assembly Materials
   - Soldering
3. State-of-The-Art Technologies
4. Manufacturing Standards
5. World Class Manufacturing – Lean Principles
6. Electronic Assembly Business (cost, benefits, outsourcing)

Package on Package

- What is Package-on-Package PoP
  - Vertical assembly of ICs or assembly in 3rd dimension
  - Introduced in 2005 and now becoming common
  - Most applications in cell phone and other small hand held devices
  - Type of parts:
    - Processor placed on the PCB, Memory on top of Processor
    - Package type: Lower BGA with connecting pad on the top of the package. Upper BGA is a standard BGA
  - Architecture
    - All signals connected from one chip to the other are routed from one package to the other vertically up

Package on Package

- Why Package-on-Package
  - Size
    - Reduces PCB size and number of layers in the PCB
    - Reduces the cost of PCBA
    - Reduces the product size
  - Performance
    - Reduces signal noise
    - Improves reliability with less via holes and trace length
    - Typically reduces 1.25m of trace length on a pair of micro-controller and memory

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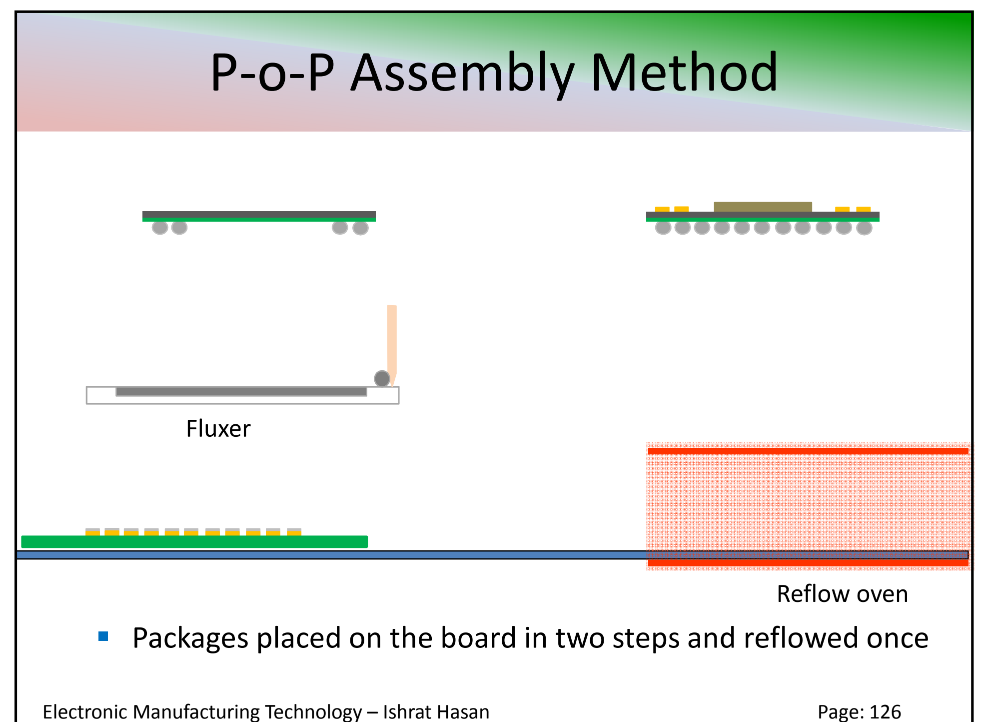
P-o-P Assembly Method



- Packages placed on the board in two steps and reflowed once

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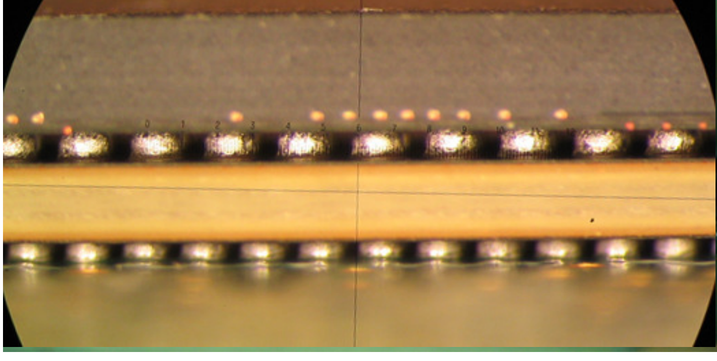
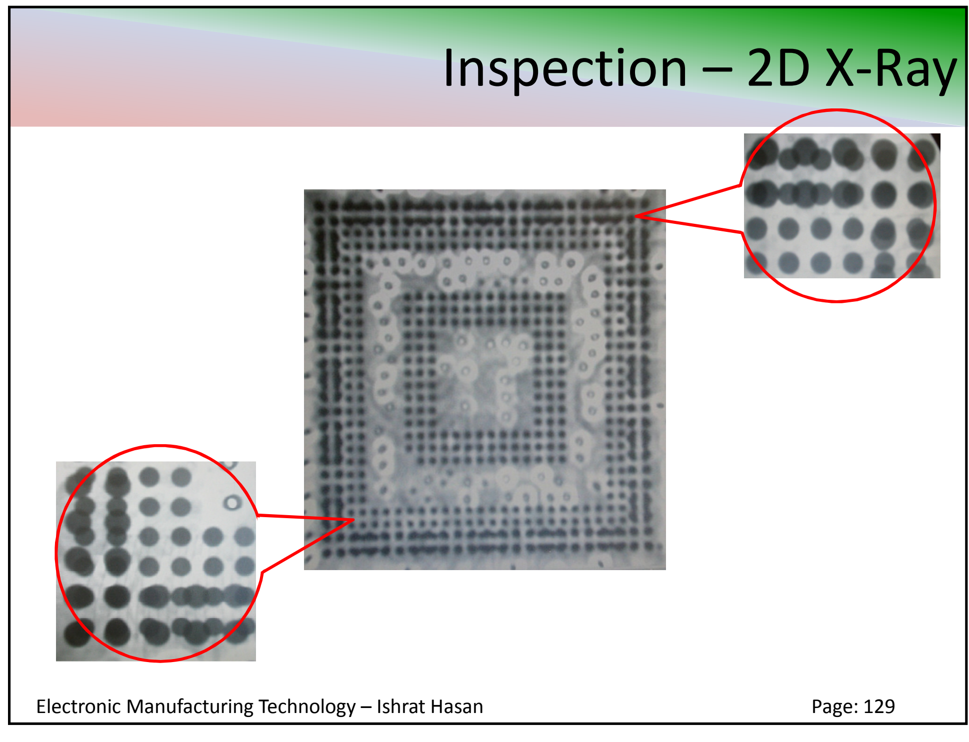
P-o-P Assembly Process

- POP Placement Process
  - Pick and Place Bottom Part
  - Pick Top part
  - Dip Top part in solder paste
  - Place Top part on the bottom part

Visual Inspection

- Inspection under microscope




Inspection – 2D X-Ray
Electronic Manufacturing Technology – Ishrat Hasan
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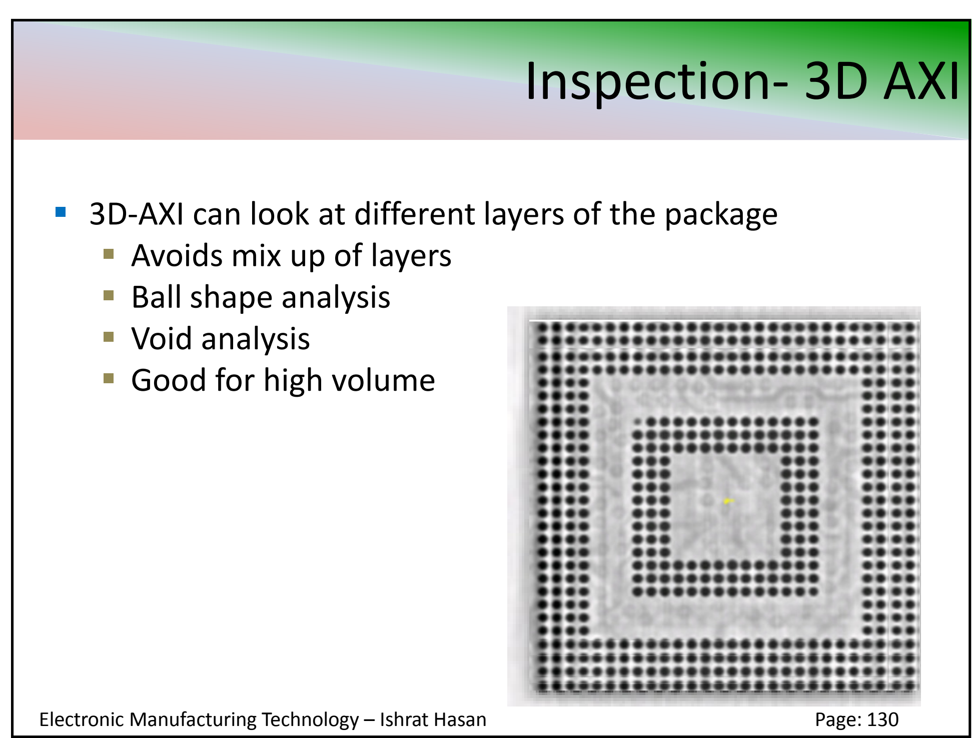
Inspection- 3D AXI
3D-AXI can look at different layers of the package
Avoids mix up of layers
Ball shape analysis
Void analysis
Good for high volume
Electronic Manufacturing Technology – Ishrat Hasan
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Agenda

1. Electronic Manufacturing
2. Manufacturing Technology
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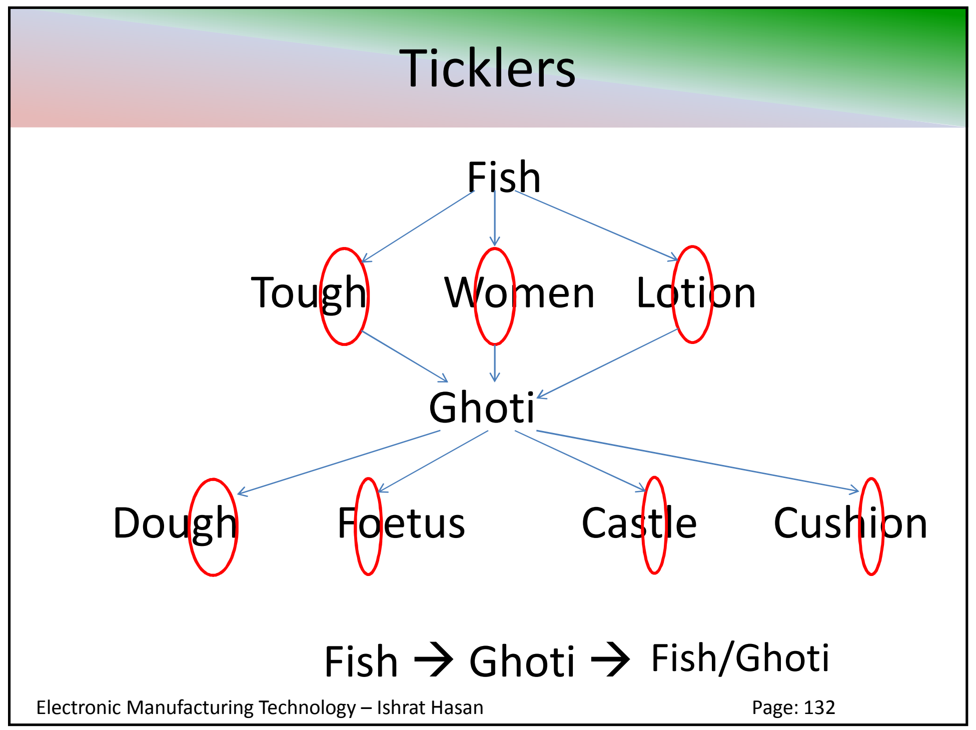
Ticklers



The Smiths were proud of their family traditions. Their ancestors had come to America on the Mayflower. They had included Senators and Wall Street wizards.

They decided to compile a family history, a legacy for their children and grand children. They hired a fine author. Only problem arose – how to handle the great uncle George, who was executed in electric chair.

The author said he could handle the situation tactfully. So he wrote.

"The Great Uncle George occupied a chair of applied electronics at an important government institution, was attached to his position by the strongest ties until his last moment. His death came as a great shock".

Moral: Depends on how you write it and how you read it

Standards

- Why do we need standards
  - A common basis of acceptance criteria for the product
  - A common goal to strive for workmanship levels
  - Removal of individual preference and likes/dislikes
  - Third party involvement as referee
  - Knowledge pool and experience of a larger group with more generalized objectives

ESD

- Sources of Static Charge in Electronic Environment
  - Work Surface: Waxed, painted surface, plastic
  - Floor: Concrete, Tiles, Carpet
  - Clothes: Synthetic materials, Hair, Shoes,
  - Personal: Plastic bottles, paper
  - Chairs: Finished woods, Fiberglass
  - Packaging Materials: Plastic wraps, Styrofoam, Cardboard box
  - Assembly Tools: Compressed air, sprays, blowers,

ESD

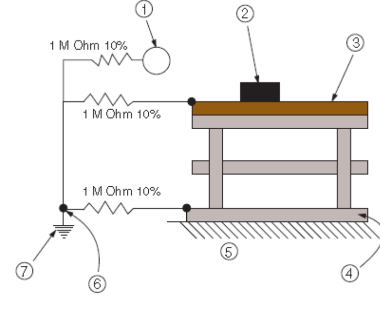
- Static Voltage

Source	10-20% Humidity	65-90% Humidity
Walking on carpet	35,000 volts	1,500 volts
Walking on Vinyl Floor	12,000 volts	250 volts
Person on the bench	6,000 volts	100 volts
Paper and Vinyl	7,000 volts	600 volts
Plastic bag picked from the bench	20,000 volts	1,200 volts
Work chair	18,000 volts	1,500 volts

ESD

- ESD Damage Prevention
  - 1- Wrist Strap
  - 2- Handling devices
  - 3- Work surface
  - 4- ESD Floor
  - 5- Building Earth
  - 6- Electrical Earth

For safe ESD environment at 100/1000 MΩ resistance, discharge time is < 0.1/1 sec



Warning Labels

Entrance of the floor

On the devices and work area

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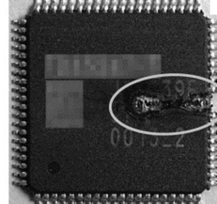
Moisture Sensitive Parts

- What is MSP phenomenon
  - The electronic components have a tendency to absorb moisture from the atmosphere.
  - In the rapid heating of the components during reflow, the absorbed moisture tries to release and in turn cracks the body or the internal traces in the die



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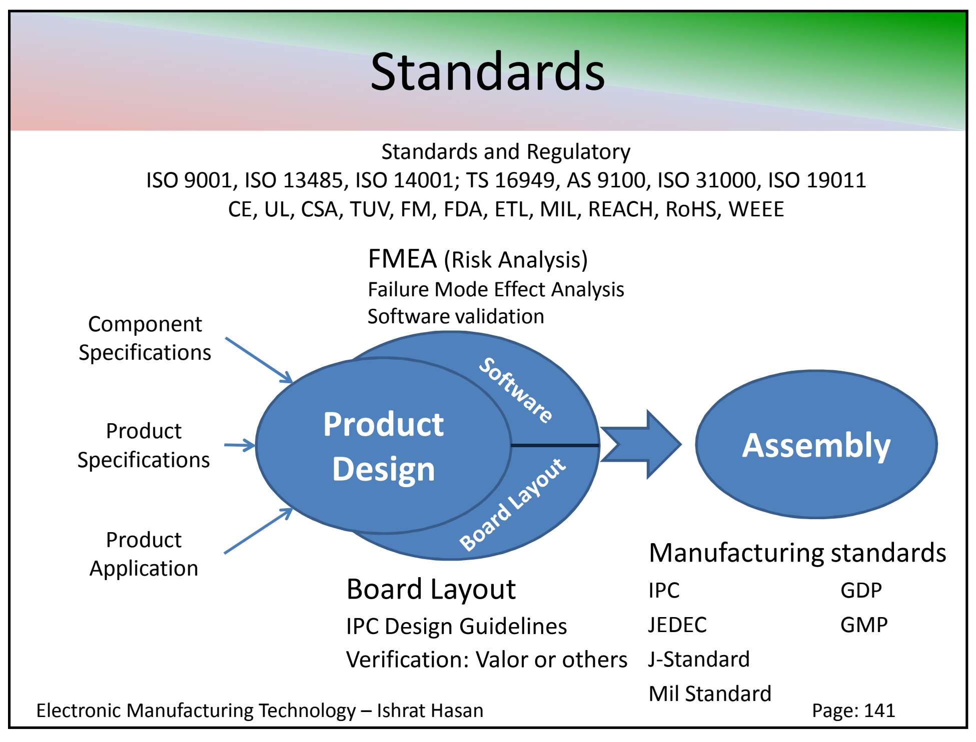
Moisture Sensitive Parts

- MSP Classification: J-STD-020B
  - Depending on the type of package, each part has different tendency of moisture absorption
  - They are categorized in Moisture Sensitive Parts Level

LEVEL	FLOOR LIFE	
	CONDITIONS	TIME (NOTE 1)
1	≤ 30°C / 85% RH	Unlimited (Note 2)
2	≤ 30°C / 60% RH	1 Year
2A	≤ 30°C / 60% RH	4 Weeks
3	≤ 30°C / 60% RH	168 Hours
4	≤ 30°C / 60% RH	72 Hours
5	≤ 30°C / 60% RH	48 Hours
5A	≤ 30°C / 60% RH	24 Hours
6	≤ 30°C / 60% RH	6 Hours

Moisture Sensitive Parts

- Handling of MSP
  - Keep the parts in moisture barrier bags and always sealed
  - Keep desiccant in the package to remove any minor moisture
  - Keep a humidity indicator card in the package to measure humidity level in the package
  - If the moisture level exceeds the limit, bake the parts to remove moisture and re-seal.
    - Baking guidelines in J-STD-033B. Typical 90°C for 24 hours
  - Never leave the parts open when not in use



Standards

Institute for **I**nterconnecting and **P**ackaging Electronic **C**ircuits

Joint **E**lectron **D**evices **E**ngineering **C**ouncil

Joint Standard

Military Standard

IPC covers clauses from all these standard

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IPC Standards

- How IPC works
  - Unanimous agreement of manufacturers on the acceptability criteria of electronic assembly
  - Most of the clauses are based on democratic process
  - The organization is supported by the industry for documenting and updating the standard based on working of sub-committee and their recommendations

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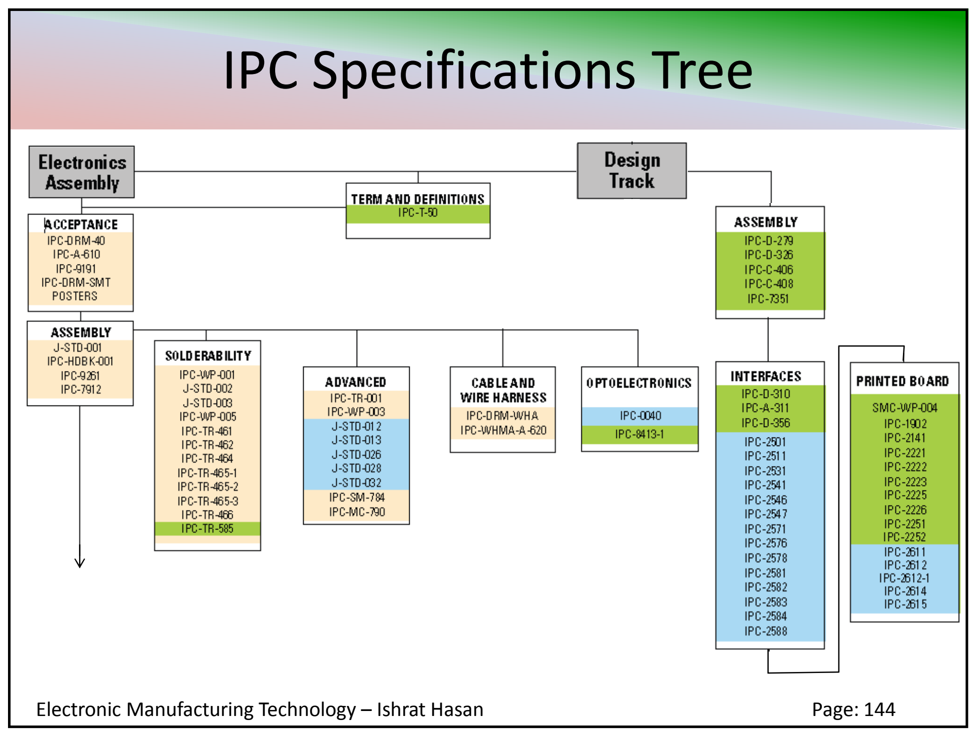

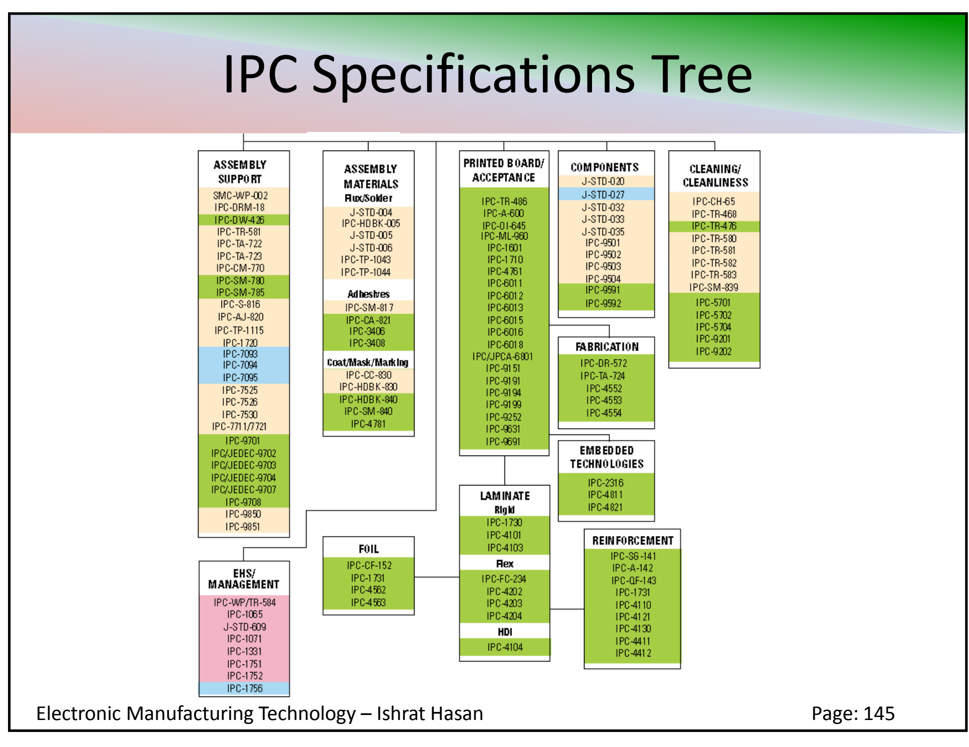

IPC Standards

- Design specifications
  - IPC- 2221 Generic Standard on Printed Board Design
  - IPC-2223 Sectional Design Standard for Flexible Printed Boards
- Material specifications
  - IPC-FC-234 Pressure Sensitive Adhesives Assembly Guidelines for Single-Sided and Double-Sided Flex PCB
  - IPC-4562 Metal Foil for Printed Wiring Applications
  - IPC-4101 Laminate Prepreg Materials Standard for Printed Boards
  - IPC-4202 Flexible Base Dielectrics for Use in Flexible Printed Circuitry
  - IPC-4203 Adhesive Coated Dielectric Films for Cover Sheets for Flexible PCB and Bonding Adhesive
  - IPC-4204 Flexible Metal-Clad Dielectrics for Use in Fabrication of Flexible Printed Circuitry
- Performance and inspection documents
  - IPC-A-600 Acceptance of Printed Wiring Boards
  - IPC-A-610 Acceptance of Printed Circuit Assembly
  - IPC-A-620 Acceptance of Cable Assembly
  - IPC-6011 Generic Performance Specification for Printed Boards
  - IPC-6013 Specification for Printed Wiring, Flexible and Rigid-Flex
  - IPC- 6202 IPC/JPCA Performance Guide Manual for Single- and Double-Sided Flexible PWB
  - PAS-62123 Performance Guide Manual for Single & Double Sided Flexible Printed Wiring Boards
  - IPC-TF-870 Qualification and Performance of Polymer Thick Film Printed Boards
- Test
  - IPC- TM-650 Test Methods

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IPC Standards

- IPC Standards for PCB Assembly:

Acceptance	IPC-610; IPC J STD-001D; IPC-A-620; IPC-SM-784 (COB); J-STD-032 (BGA); IPC-SM-785 (Reliability Testing), IPC-TM-650
Cleaning	IPC-M-108
Components	IPC-DRM-18
General	IPC-M-103 (Surface Mount Assemblies); IPC-M-104 (Printed Circuit Board)
Materials	J-STD-004A (Soldering Fluxes); J-STD-006 (Solder Alloys for electronics)
Process Support	IPC-SM-780 (Component Packaging and Interconnect)
Rework and Repair	IPC-7711/7721
Solderability	J-STD-002; J-STD-003
Conformal Coating	IPC-CC-830B

IPC Standards

- Design

Guidelines	IPC-2220
Land Pattern	IPC-7351 (formerly SM-782)

- Printed Circuits

Acceptance	IPC-A-600; IPC-6010
Fabrication	IPC-2615; IPC-6013

IPC Standards

- Others

Moisture Sensitive Parts	IPC JEDEC J STD-020 Moisture Sensitivity Classification IPC JEDEC J STD-033 Standard for Handling, Packing and Shipping of MS Devices

- EOS/ESD

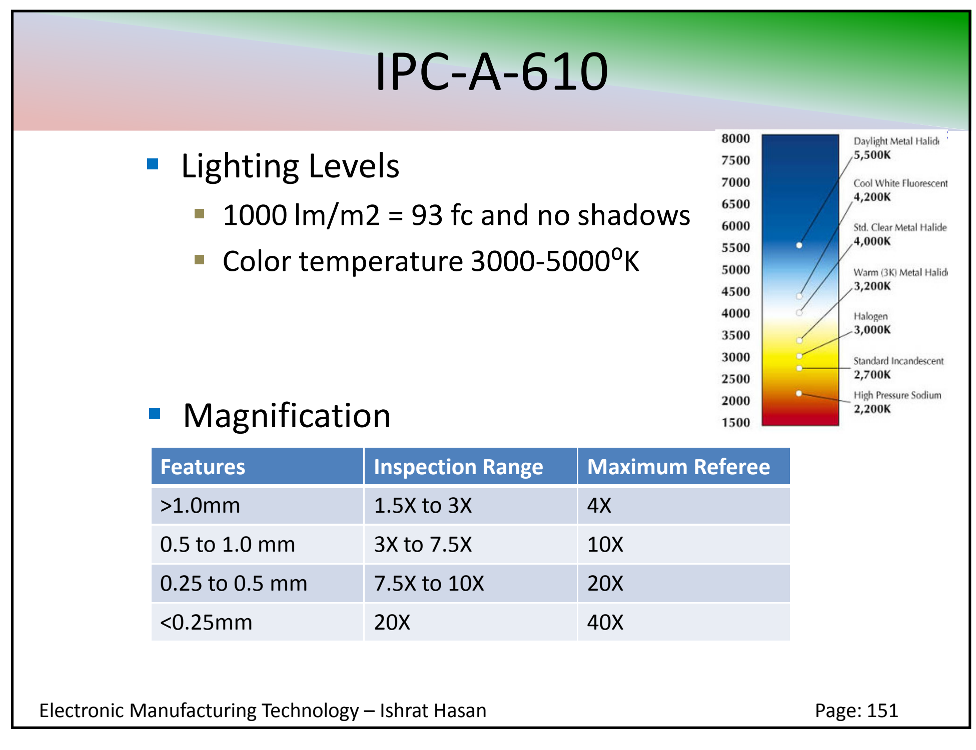
Guideline	ANSI/ESD-S-20.20

IPC-A-610 Acceptability of Electronic Assemblies

- **Class 1 — General Electronic Products**
  Includes products suitable for applications where the major requirement is function of the completed assembly.
  Example: Consumer products

- **Class 2 — Dedicated Service Electronic Products**
  Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically the end-use environment would not cause failures.
  Example: Industrial products, monitoring devices, computers, non-critical medical devices,

- **Class 3 — High Performance Electronic Products**
  Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.
  Examples: Implanted devices, Military, Life saving devices



Features	Inspection Range	Maximum Referee
>1.0mm	1.5X to 3X	4X
0.5 to 1.0 mm	3X to 7.5X	10X
0.25 to 0.5 mm	7.5X to 10X	20X
<0.25mm	20X	40X

IPC-A-610

1- General
2- Applicable Documents
3- Handling Electronic Assemblies
4- Hardware
5- Soldering
6- Terminal Connection
7- Through Hole Technology
8- Surface Mount Assemblies
9- Component Damage
10- Printed Circuit Board and Assemblies
11- Discrete Wiring
12- High Voltage

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IPC-A-610

- Acceptability Criteria
  - Meets Form, Fit and Function
    - Example: Electrical shorts, Opens, Physical requirements for connector mating
  - Does not violate the criteria for electrical clearance
  - Potential of damage with time
    - Example: Cable kinks, sharp bends on leads
  - Customer acceptance criteria
    - Defined through specifications, agreements, POs etc.
  - Process indicator
    - Not a defect but may potentially fail if controls not implemented

IPC-A-610

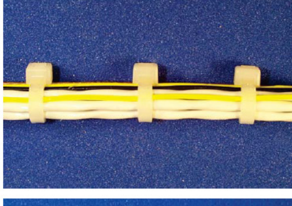
- Inspection Method:
  - Purely visual, through naked eyes, magnifier or microscope
  - Distances are estimated and compared
  - No measurement required
  - No electrical tests, mechanical verification or chemical testing required
  - IPC does not specify sample sizing or minimum AQL

IPC-A-610

- The following pages are only selected examples of IPC-A-610 for acceptability criteria electronic assemblies
- This training is covered in five full days for inspectors and it is a certification program

IPC-A-610

- Cable Assembly

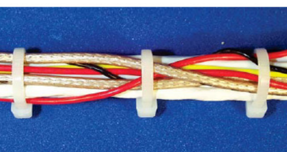


Target - Class 1,2,3

- Wire lay is parallel to the axis of the bundle with no cross-over.
- Coaxial cable secured with tie wraps/straps.

Acceptable - Class 1,2,3

- Wires twist and crossover, but bundle is uniform in diameter.



Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Wires twist and crossover underneath a tie wrap/strap.

Acceptable - Class 1
Defect - Class 2,3

- Bundle is not uniform in diameter.
- Excessive crossover.

Defect - Class 1,2,3

- Any kinks that violate minimum bend radius.
- Wire insulation is damaged, see 6.2.1.

IPC-A-610

- Solder Coverage

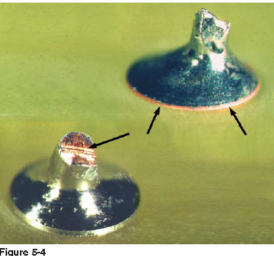


Figure 5-4

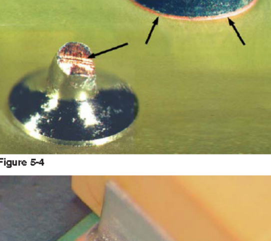


Figure 5-5

Acceptable - Class 1,2,3

- Exposed basis metal on:
  - Vertical conductor edges.
  - Cut ends of component leads or wires.
  - Organic Solderability Preservative (OSP) coated lands.
- Exposed surface finishes that are not part of the required solder fillet area.

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IPC-A-610

- Solder Defects

Figure 5-8

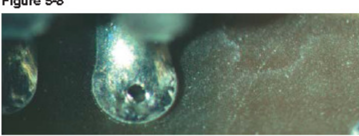
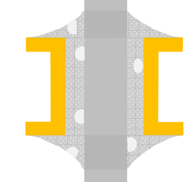


Figure 5-9

Acceptable - Class 1
Process Indicator - Class 2,3

- Blowholes, Figures 5-8,9, pinholes, Figure 5-10, voids, Figures 5-11,12, etc., providing the solder connection meets all other requirements.



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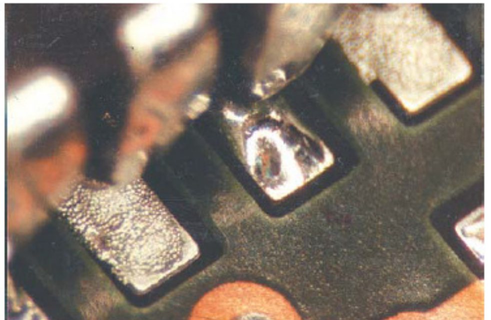
IPC-A-610

- Incomplete reflow

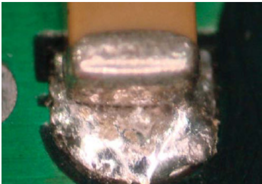


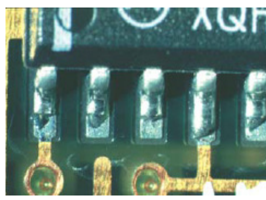
Defect - Class 1,2,3

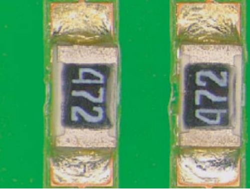
- Incomplete reflow of solder paste.

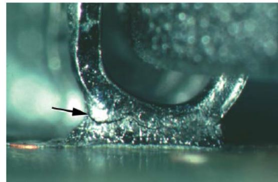
IPC-A-610

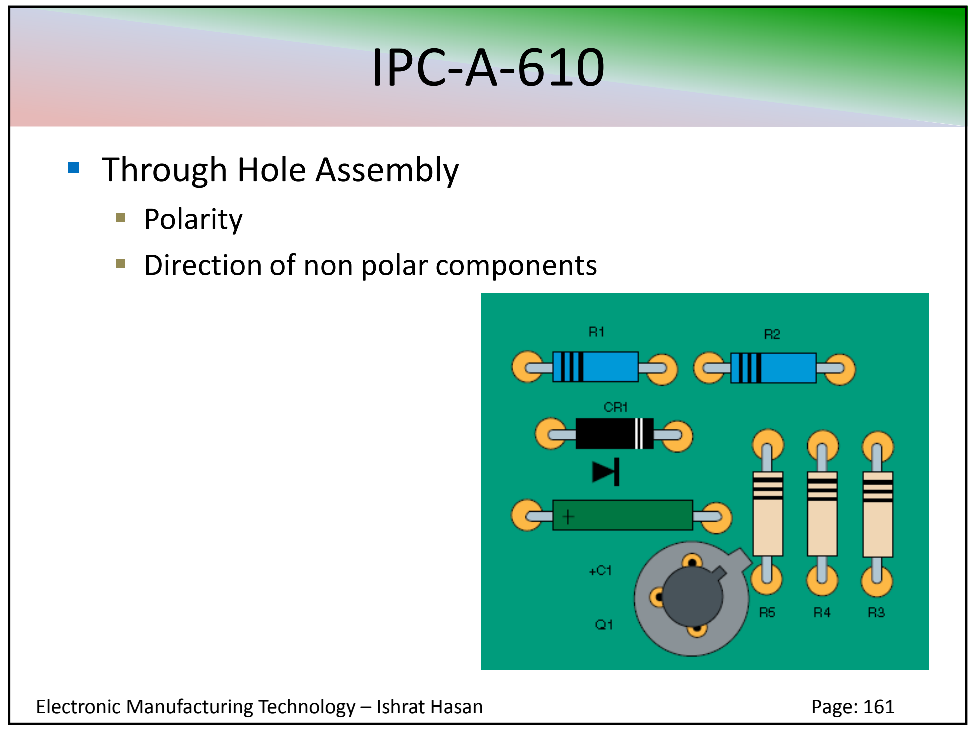
- Other solder defects
  - Non-wetting
  - De-wetting
  - Solder Balls
  - Excess Solder
  - Disturbed solder
  - Fractured solder










IPC-A-610
Through Hole Assembly
Polarity
Direction of non polar components
R1
R2
CR1
+C1
Q1
R5
R4
R3
Electronic Manufacturing Technology – Ishrat Hasan
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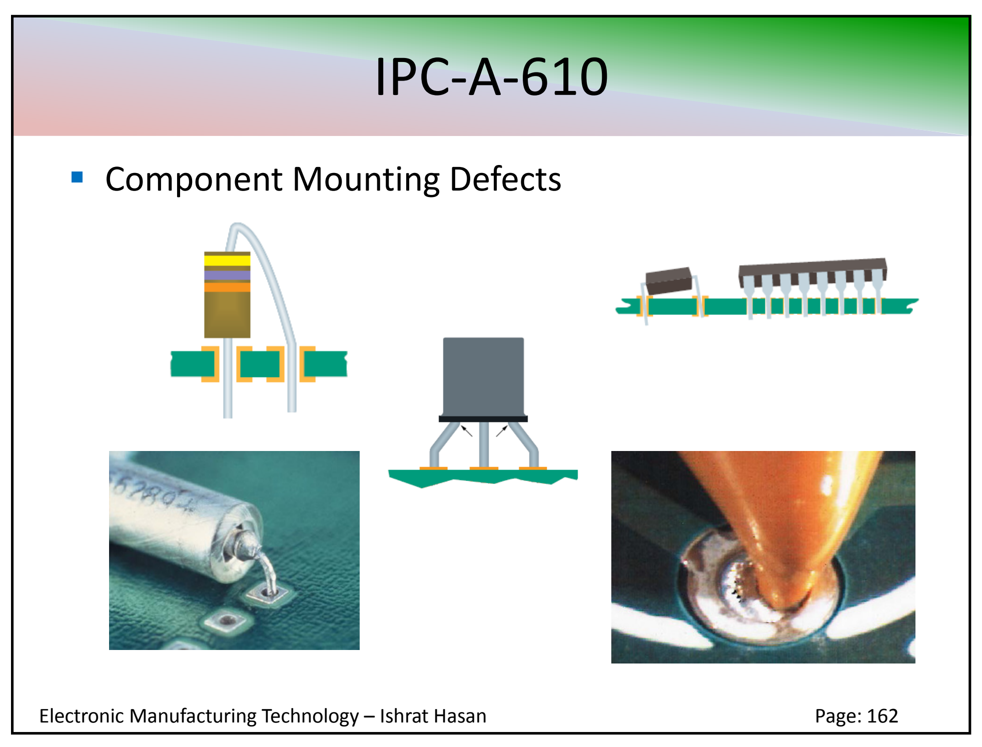
IPC-A-610
Component Mounting Defects
Electronic Manufacturing Technology – Ishrat Hasan
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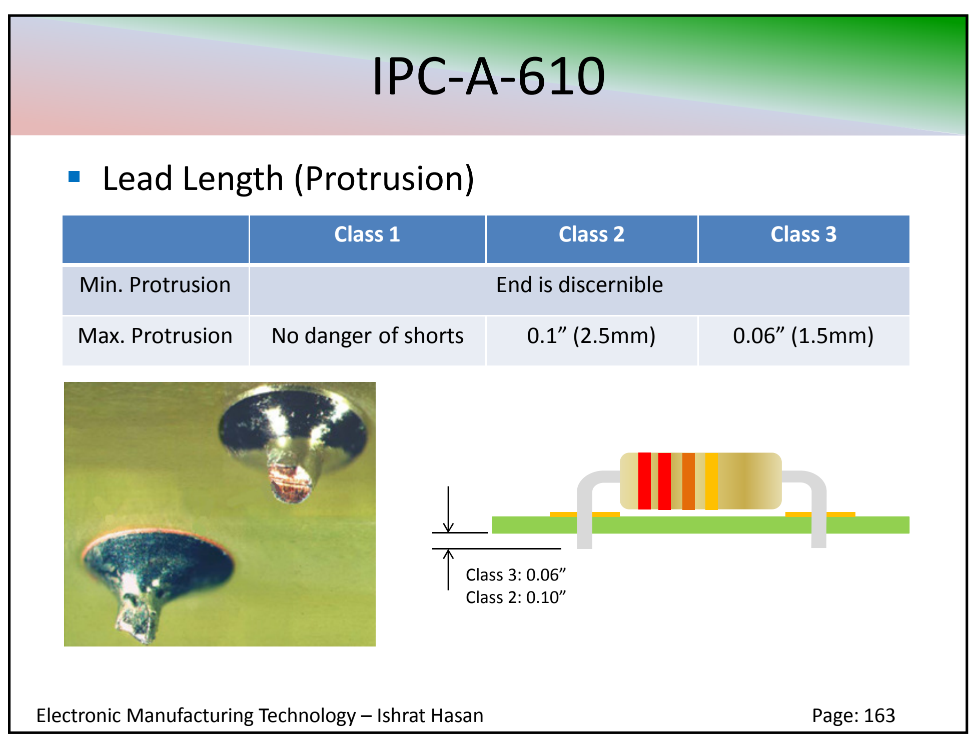
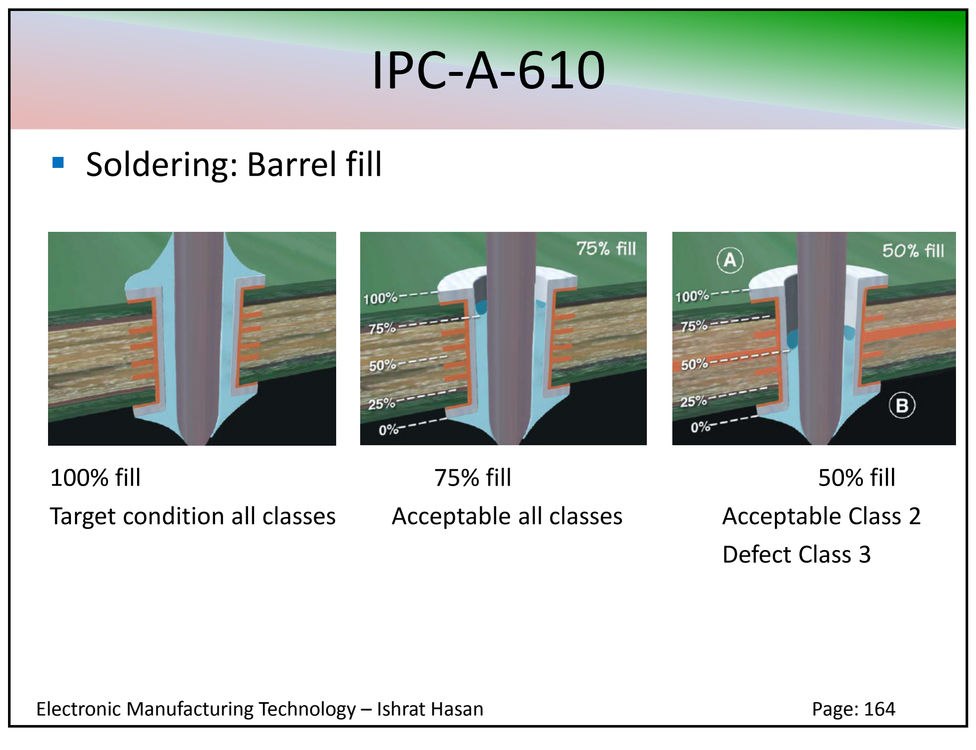
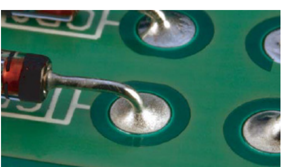


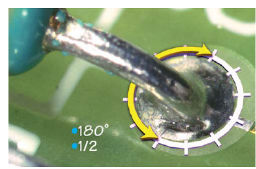
	Class 1	Class 2	Class 3
Min. Protrusion	End is discernible		
Max. Protrusion	No danger of shorts	0.1” (2.5mm)	0.06” (1.5mm)

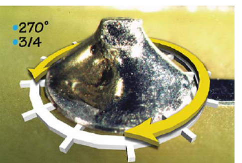


IPC-A-610

- Solder- Circumferential coverage







100% coverage
Acceptable all classes

Partial coverage Top side and Bottom side

	Top side	Bottom side
Acceptable Class 2:	Min 180°	Min 270°
Acceptable Class 3:	Min 270°	Min 330 °

IPC-A-610

- SMT Part Alignment on Land

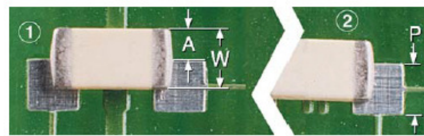
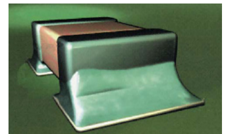
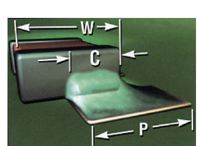


Figure 8-19
1. Class 2
2. Class 3

Acceptable - Class 1,2
- Side overhang (A) is less than or equal to 50% width of component termination area (W) or 50% width of land (P), whichever is less.

Acceptable - Class 3
- Side overhang (A) is less than or equal to 25% width of component termination area (W) or 25% width of land (P), whichever is less.



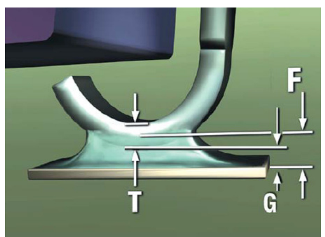


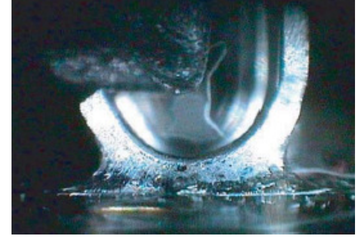
Target - Class 1,2,3
- End joint width is equal to component termination width or width of land, whichever is less.

Acceptable - Class 1,2
- End joint width (C) is minimum 50% of component termination width (W) or 50% land width (P), whichever is less.

IPC-A-610

- SMT Solder Joint



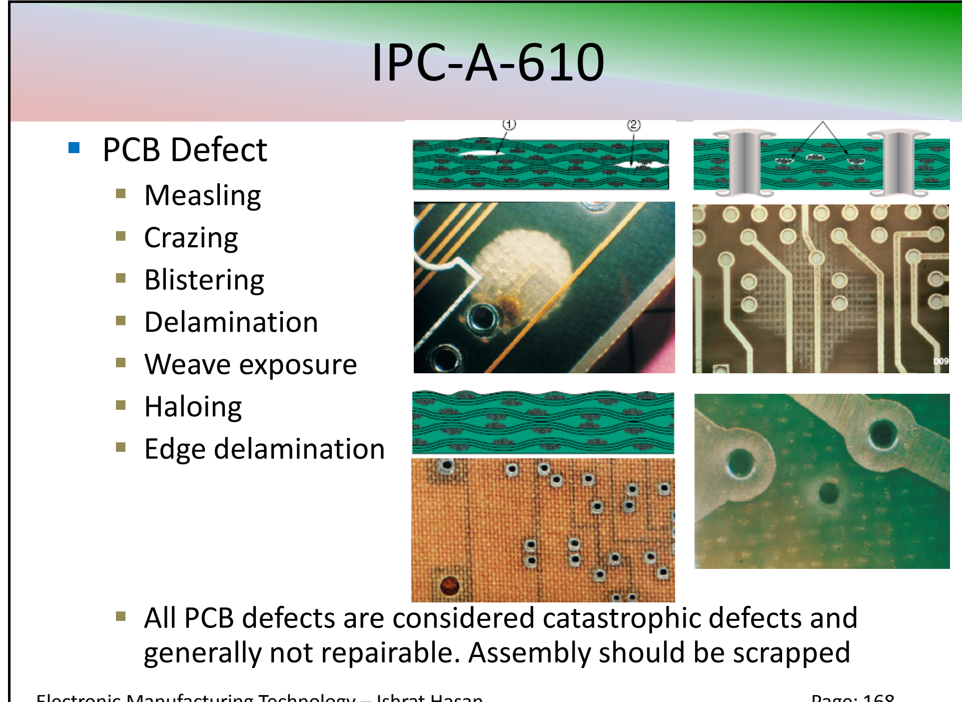


Acceptable - Class 1,2

- Heel fillet height (F) is minimum 50% lead thickness (T) plus solder thickness (G).

IPC-A-610

- PCB Defect
  - Measling
  - Crazing
  - Blistering
  - Delamination
  - Weave exposure
  - Haloing
  - Edge delamination

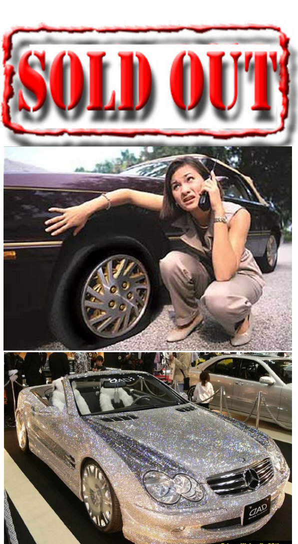


  - All PCB defects are considered catastrophic defects and generally not repairable. Assembly should be scrapped

Quality

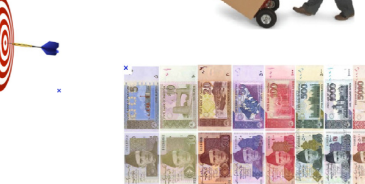
What Quality means to you?

- The product is available when you need it
- It works for the expected life of the product and performs beyond your expectation
- Eye pleasing- looks and feel
- It suits your budget



Quality Expectation

- If we meet the four basic expectations of our customers, i.e. Delivery, Performance, Cost and Service, it is considered as good quality
  - Shipped in time
  - Has no defects
  - Meets the cost target
  - All questions answered



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What bad quality means

- If the quality level is **1.0%** reject rate. This means
  - **2,500** products out of 250,000 would return
  - **1** wrong medicine prescribed from an average sized pharmacy daily
  - If you drive daily to work, you will have an accident every **100th** day
  - **1** flight accidents every day at Karachi Airport (137 flights daily)
  - **864** missed heartbeat every day. One missed beat could be fatal – 86400 beats per day

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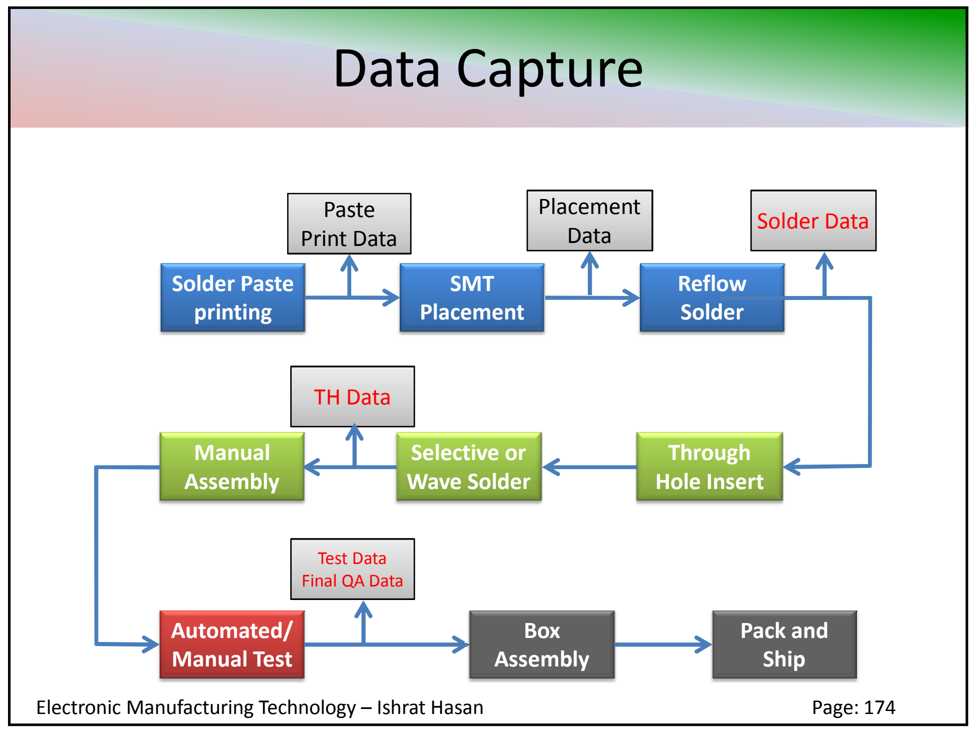
Quality In Electronic Assembly

- Data capture
  - Set up appropriate data collection locations
  - Strive for efficient, accurate and complete data
  - Automate test data capture
- Data reporting
  - Format data for meaningful reporting
  - Share data at the appropriate forums and assign improvement actions
- Industry standards
  - Compare your data with industry standards for bench marking purposes

Data Capture



Data Capture

- Critical Data Capture Points:
  - Placement and Reflow data collected at post reflow inspection
  - Through Hole data collected post wave solder
  - Test yield data collected during test

SMT Data | TH Data | Test Data

SMT Placement and Reflow → TH Insertion and Wave Solder → ICT/FP/ Functional Test →

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Data Capture

- Data Collection Method – Database
  - System setup
    - Date/Time
    - Assembly number
    - Job number
    - Assembly Parameters
      - BOM
      - Opportunity count
    - Data collection points
    - Operator name
    - Reminders and Warning
    - Standard defect list → Reflection of IPC defect codes

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Data Handling

- Assembly Parameters
  - BOM

Assembly level	Part #	Description	Status	Item Seq	Op Seq	Unit of Measure	Quantity	Yield	Ext Quantity	Ref. Designator	Alternate Part #
1	12345	Resistor 100R, 10%, SMT 0603	Active	20	10	Ea	1	1.10	1.1	R25	12489
1	34214	IC D343RN, Interface, SOIC8	Active	30	10	Ea	1	1	1	U43	

  - Opportunity Count

    Total possibilities of mistakes on an assembly. Part

- Parts opportunity→ Wrong parts: Count of parts 250
- Placement opportunity→ Missing part, wrong polarity: Count of parts 250
- Soldering opportunity→ Bridging, Open solder joint: Count of pins 2300
- Assembly opportunity→ Assembly scrap: Count of assembly 1
- Total opportunity count per board **2801**

Data Handling

- Standard defect list

Defect Description	Defect Category	Defect Description	Defect Category
Assembly not clean	Assembly	Un prepped part	Component
Conformal coating not present where required	Assembly	Wire not tinned when required	Component
Conformal coating peeling	Assembly	Bill Boarding	Placement
Conformal coating present where not wanted	Assembly	Crimped wrong	Placement
Solder balls/splash	Assembly	Lead/cable routing wrong	Placement
Bent lead	Component	Min. elect clearance violated	Placement
Blisters, measling, peeling, delamination	Component	Missing Part	Placement
Electrically Defective Component	Component	Misaligned Part	Placement
Improper stress relief	Component	Tilted part	Placement
Incorrect terminal flange	Component	Tombstone	Placement
Insulation clearance wrong	Component	Wire connected wrong	Placement
Insulation or wire conductor damage	Component	Wire routing wrong	Placement
Lead forming wrong	Component	BGA Voids	Termination
Lead/cable length wrong	Component	Blow holes	Termination
Leads not tinned	Component	Cold solder joint	Termination
Marking incorrect	Component	Disturbed solder joint	Termination
Damaged Part	Component	Fractured solder joint	Termination
Part lead stressed	Component	Icicles	Termination
PCB Contamination on gold fingers	Component	Insufficient solder / fillet	Termination
PCB exposed copper / contamination	Component	Lead protrusion wrong	Termination
Plating or other part finish problem	Component	Part coating meniscus in joint	Termination
Sleeving problem	Component	Solder bridge	Termination
Solderability problem	Component	Solder wetting unacceptable	Termination
Spliced where not permitted	Component	Unsoldered connection	Termination

Data Handling

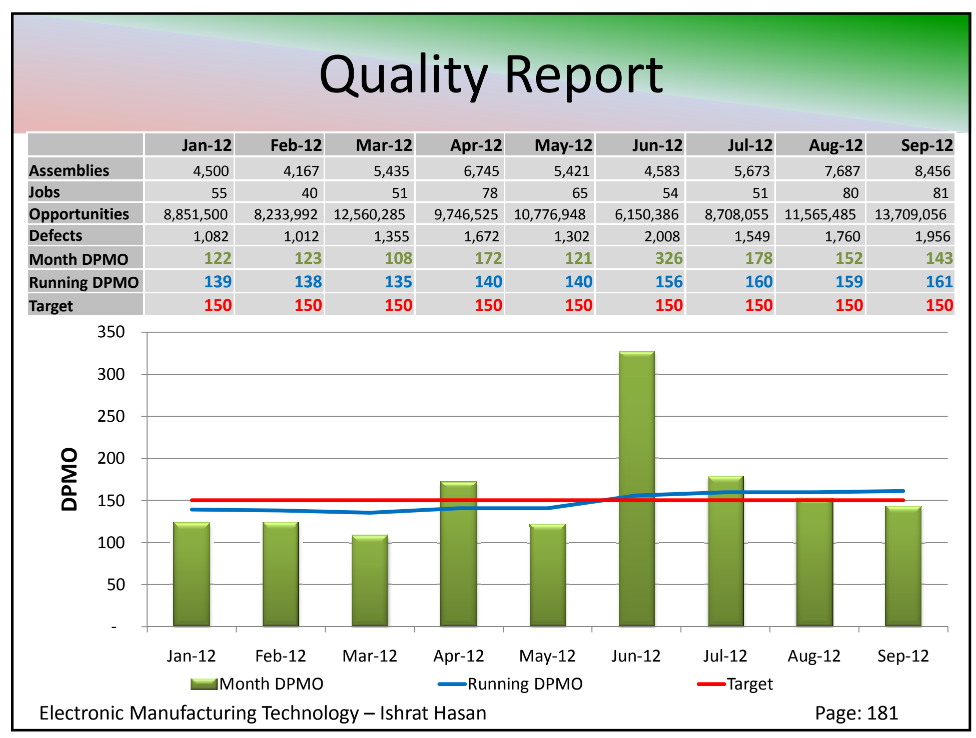
Date	Time	Inspector	Assembly #	Rev	Job #	Step	Serial #	Ref. Desig	Part #	Defect	Comments
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	C1	87667	Missing part	
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	C10	87623	Missing part	
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	R11	23451	Missing part	
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	C16	43142	Missing part	
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	C121	54613	Open pin	
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	R131	54435	Missing part	
1-Oct-12	10:27AM	ABC	123	A	34567	10	1AA1234	R133	45112	Open pin	
1-Oct-12	10:32AM	ABC	123	A	34567	10	1AA1244	C14	34113	Wrong part	
1-Oct-12	10:32AM	ABC	123	A	34567	10	1AA1244	C10	87623	Missing part	
1-Oct-12	10:32AM	ABC	123	A	34567	10	1AA1244	C16	43422	Tombstone	
1-Oct-12	10:32AM	ABC	123	A	34567	10	1AA1244	U211	42134	Missing part	
1-Oct-12	10:36AM	ABC	123	A	34567	10	1AA1245	C10	14611	Missing part	

Quality Report

- Quality Report
  - For the job quantity of 100 boards and opportunity count of 2801 on each board, the total defects at SMT are:
  - Part defects: 15
  - Solder defects: 23
  - Total defects: 38
  - Total opportunities/board: 2801
  - Total opportunities for the job: 280,100
  - Defects per Million opportunities: 1,000,000 x 38/280,100

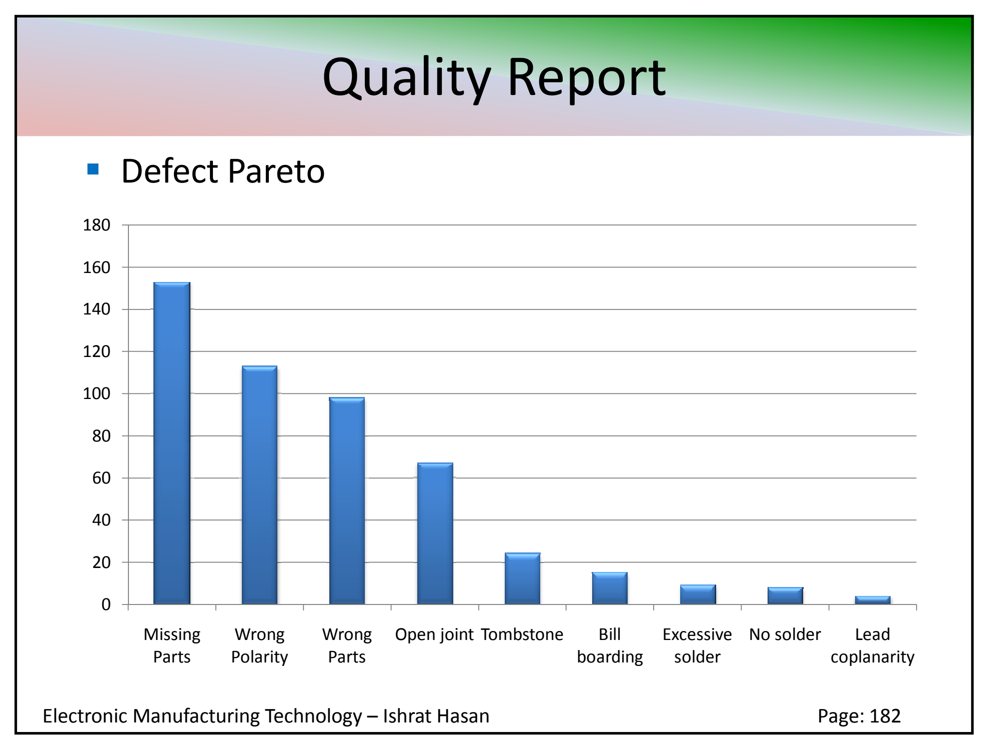
    135 DPMO

DPMO is the standard mode of expressing assembly defects



Quality Report

	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
Assemblies	4,500	4,167	5,435	6,745	5,421	4,583	5,673	7,687	8,456
Jobs	55	40	51	78	65	54	51	80	81
Opportunities	8,851,500	8,233,992	12,560,285	9,746,525	10,776,948	6,150,386	8,708,055	11,565,485	13,709,056
Defects	1,082	1,012	1,355	1,672	1,302	2,008	1,549	1,760	1,956
Month DPMO	122	123	108	172	121	326	178	152	143
Running DPMO	139	138	135	140	140	156	160	159	161
Target	150	150	150	150	150	150	150	150	150



Quality Report

- Defect Pareto

Quality Improvements

- Quality improvements based on quality data
  - Global approach for improvement
  - Data analysis to identify the top defect
  - Normalized data based on the number of boards built
  - Review data for top contributor project
  - Review data for top contributor type of part
  - Review data for top contributor **package** type

Quality Improvements

- Possible causes for the top defect (Missing parts)
  - Feeder indexing not bringing the part in dead center of pick up point, thus part picked on the end and dropping before being placed
  - Dirty nozzle losing vacuum and not able to hold the part
  - No or minimum paste on the pad causing the part not to stick to the location
  - Air draft in the reflow oven blowing the part away

Quality Improvements

- Improvement Activities
- Use any of the quality tools for improvement
  - Six Sigma Tools – DMAIC
  - Root Cause Analysis – 5 Why, 5 W, 9 squares
  - DoE
  - Corrective Actions: 8D
  - Risk Management: FMEA
  - Control Plans
  - G R&R, (Repeatability and Reproducibility)
  - GD&T, (Geometric Dimensioning and Tolerance)
  - SPC
  - PPAP
  - Cost of Quality