

Electronics Design and Manufacturing

EE20194: Group Design and Professional Engineering Practice II

Lectures 2/6 and 3/6

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Today's lecture

- Printed circuit boards
 - Double and multi-layer boards
- Board population
 - Pick & place machines
- Soldering
 - Infrared reflow
 - Vapour-phase reflow
 - Wave soldering



Board types

- Different types:
 - Single-sided (copper on one-side only)
 - Double-sided (copper on both, can have *plated-through-hole and/or vias*)
 - Multi-layer (copper on all planes- has internal layers, complex *vias: blind, buried*)
- Dielectric substrates
 - FR4 (standard material – glass-fibre based)
 - Radio Frequency boards – PTFE (teflon) based
 - Exotic (expensive) materials: alumina, quartz (GHz)

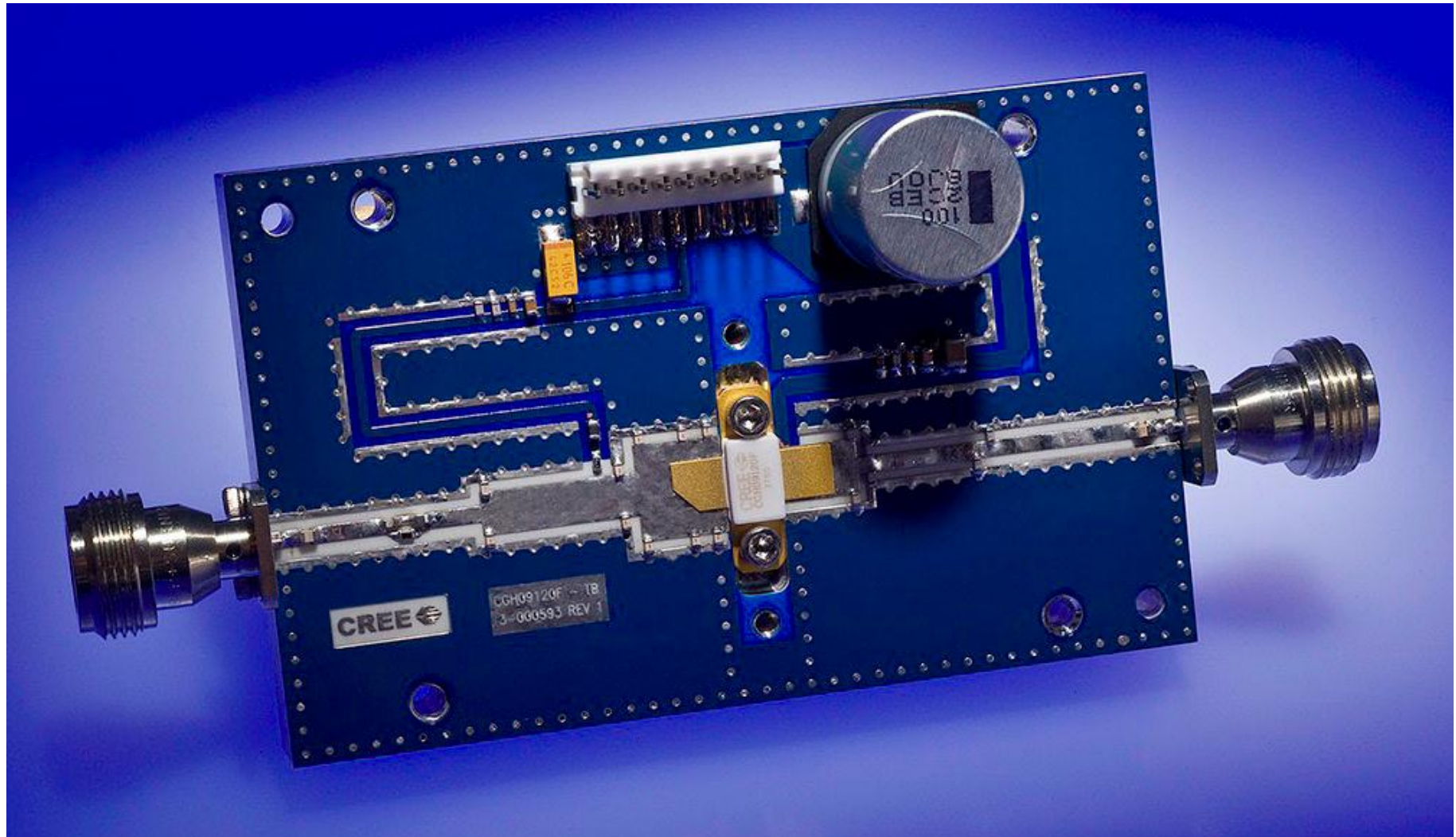
Conductors & dielectrics

- Conductive layers in PCB made from copper
 - Cu foil is bonded to board under heat and pressure
 - specified by weight per unit area (“1 oz copper” is about 35 μ m thick, “½ oz copper” is about 18 μ m thick)
 - Called “copper-clad” board or “laminates”
- Boards (also known as substrates are dielectric)
 - Different thicknesses (0.8mm, 1.0mm, 1.6m)
 - Different dielectric constants (FR4 typically 4.6-4.9)
 - Dielectric constant is complex – imaginary part is related to loss - “the loss tangent” – important for RF

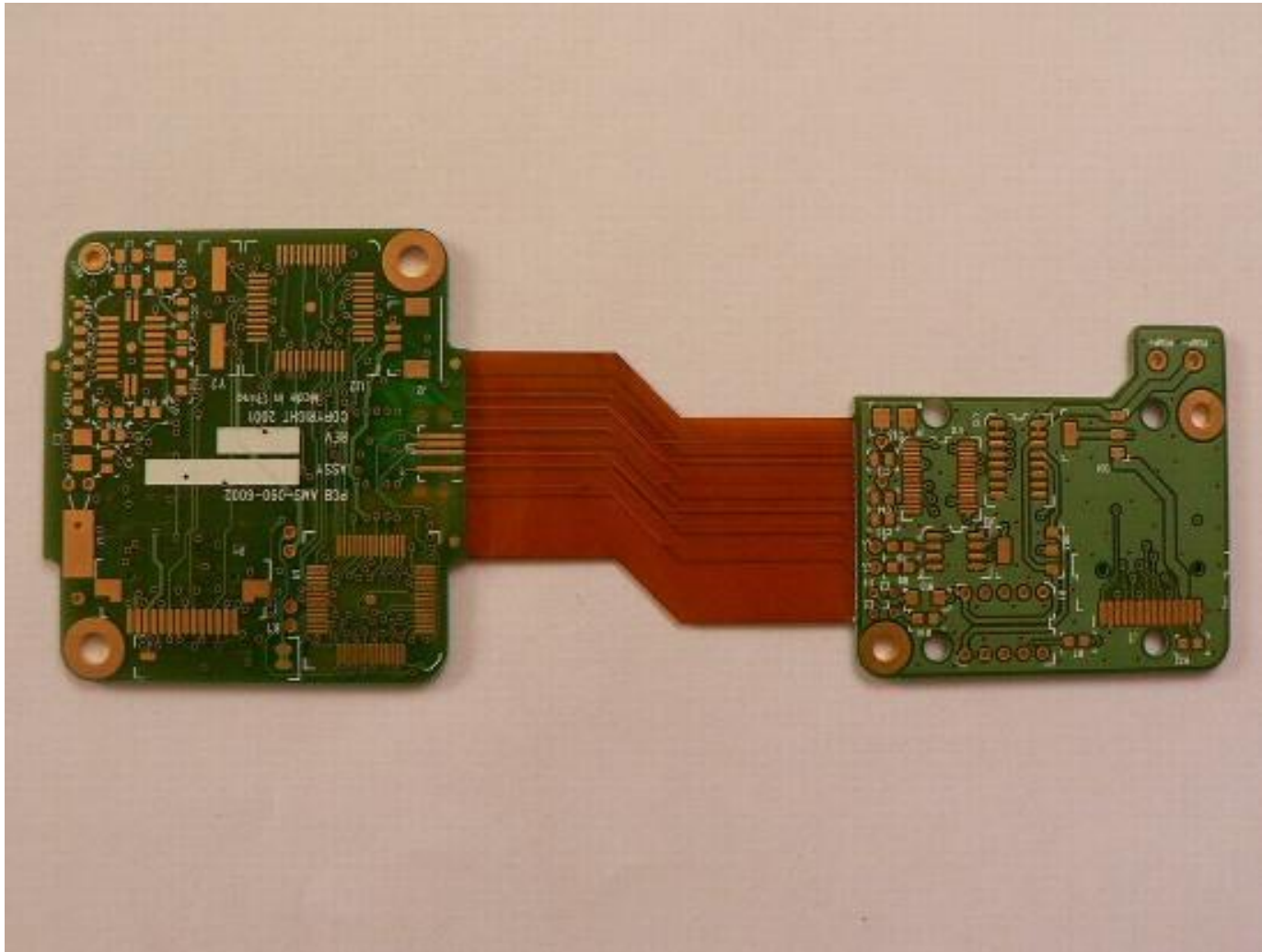
Printed circuit boards (III)

- Dielectric substrates (boards)
 - Phenolic resin bonded paper (FR2 used for Veroboard/stripboard)
 - Epoxy-glass (FR4) most widely used rigid boards
 - Polytetrafluoroethylene (PTFE) based boards
 - Polyimide (aka Kapton), solderable flexible board
 - Polyester (aka Mylar), flexible “tails” used on connectors
- Low-loss boards for RF engineering
 - Rogers: RT/Duroid, RO4350 <http://www.rogerscorp.com>
 - Taconic: TacLamPLUS <http://www.taconic-add.com>
 - Aluminium backed for power amplifiers

Aluminium backed RF board (Cree)



Rigid and flexible PCBs



Single-sided

- Most production methods use a series of chemical processes
- Chemical resistant inks screen printed onto boards, covering required copper
- Chemical etchants: ferric chloride or ammonium persulfate
- Clean board (water, solvents, acids)
- Protect tracks – tin/lead, tin or nickel/gold plate
- Protect board – solder resist
- Apply component legends & labels (aka “silkscreen”)

Double-sided

- Start with 18 μm Cu board
- Drill all holes slightly larger than required
- Electroplate entire board up to 35 μm Cu
- Apply etch resistant covering over required Cu
- Etch unwanted Cu
- Protect tracks – tin, tin/lead or nickel/silver/gold plate
- Protect board – solder resist
- Apply component legends & labels (aka “silkscreen”)

Multi-layer boards

- Basically a sandwich of lots of thin boards
- Etch internal layers
- Bond layers together in a press
- Drill holes
- Plate holes
- Etch outer layers
- Apply solder resist
- Apply silkscreen



Example prototype board pricing

- Prototype PCB costs from PCB Pool
 - 100mm x 80mm double-sided, soldermask, top side silkscreen
- Prototype board houses
 - <http://www.pcbtrain.co.uk/>
 - <http://www.pcb-pool.com/>
 - <http://www.olimex.com/pcb/index.html>

Other prototyping methods

- PCB milling – mill (cut away) the material you don't need
- Laser ablation – vapourise the copper you don't need
- Department has an LPKF S43 - arrived this Tuesday!
- <http://www.lpkf.com>

Protecting board and tracks

- Tracks
 - HASL (Hot air solder levelling)
 - Roller tinned
 - Chemical plating process for tin, nickel and gold
- Boards
 - Solder resist (or solder “mask”)
 - helps keep solder on the pads and not wick along the tracks
 - protects board and provides a base layer for “silkscreen”
 - traditionally dark green – many colours these days
 - Conformal coating – spray/dip an acrylic, polyurethane or silicone covering over board. Protects against grease, oxidation, condensation etc – after population of board

Board population: Pick & Place

- Solder paste is applied using a screen-printing process
 - Pick-up components using a vacuum tool
 - Position and place components onto board
 - Really, really fast!
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- Videos from manufacturer Essemtec.com
 - http://www.youtube.com/watch?v=U9f_RDS3J-U
 - http://www.youtube.com/watch?v=S8qkaTsr2_o

Soldering methods

- Electrically (also mechanically and thermally) bond components to a printed circuit board
- Low volume
 - Through-hole: hand soldering
 - Surface-mount: hot-air reflow
- High volume
 - Through-hole: wave soldering
 - Surface mount: infrared or vapour phase reflow (can wave solder some SMT devices)

What is solder?



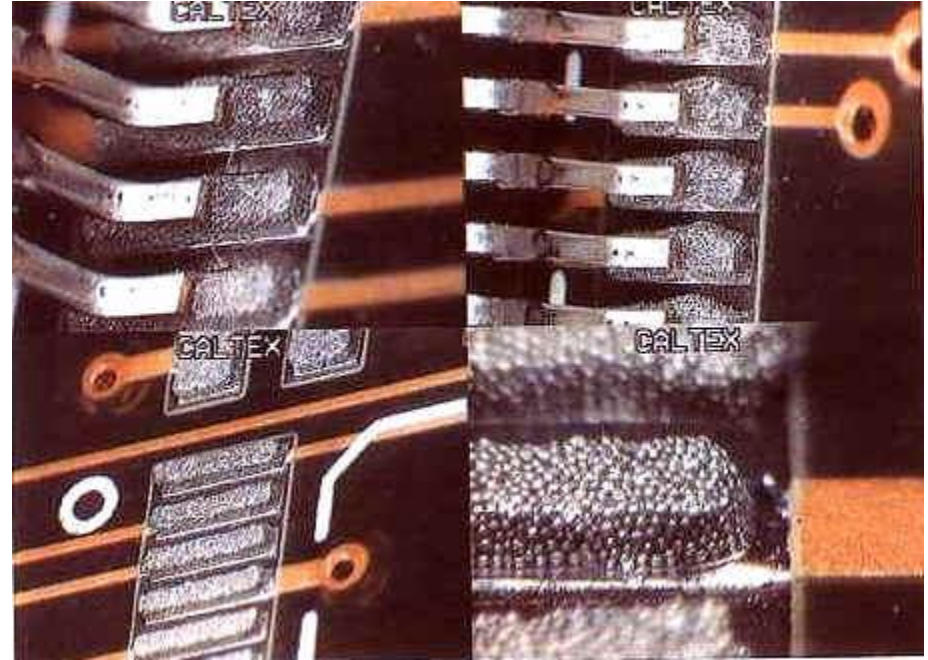
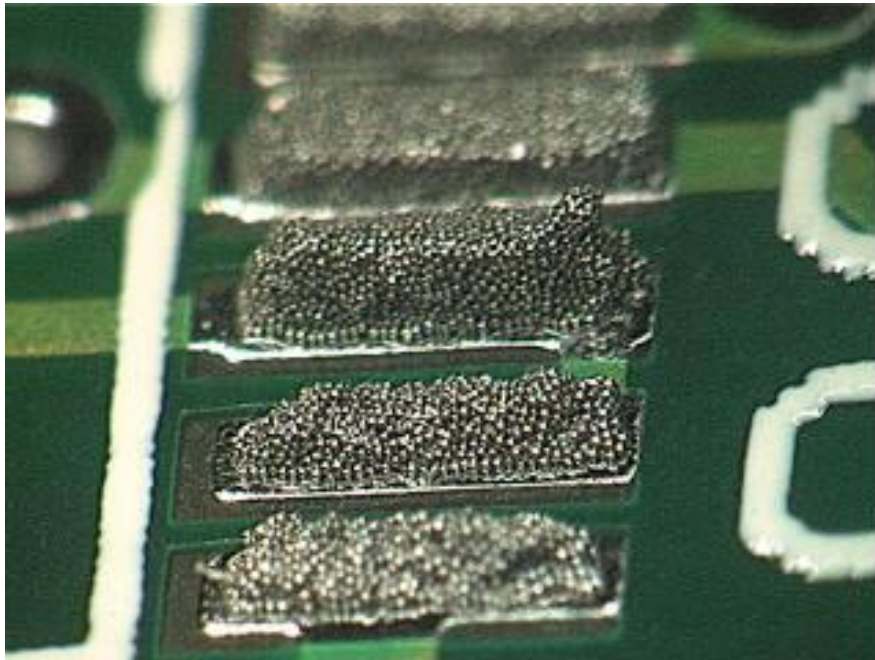
- Solder
 - Eutectic alloy – combination of metals that have lowest possible melting temperature
 - Solder wire often contains flux, a cleaning agent
- Leaded solder (many variants)
 - Non RoHS: $\text{Sn}_{63}\text{Pb}_{37}$ (Tin and Lead)
 - Melting temperature around 185°C
- Lead-free solder (many variants)
 - RoHS compliant: $\text{Sn}_{96.5}\text{Ag}_{3.0}\text{Cu}_{0.5}$ (Tin, Silver & Copper)
 - Melting temperature around 220°C

RoHS

- RoHS – Restriction of Hazardous Substances
 - Banned materials: lead, cadmium, mercury + others
 - European Union, list of banned substances
 - <http://www.bis.gov.uk/nmo/enforcement> (UK)
 - “China RoHS” (similar but list of permitted substances)
 - <http://www.rohs.gov.cn/> (China)
- Exemptions in certain areas (restricted sales)
 - Military
 - Aerospace
 - Space

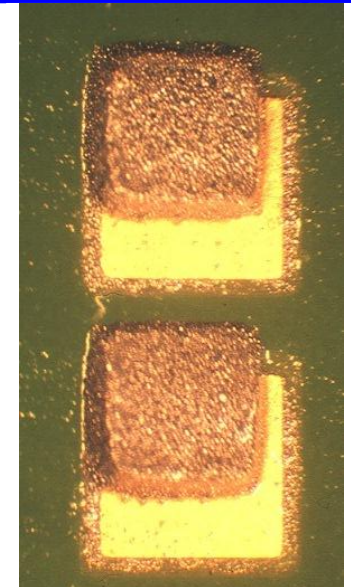
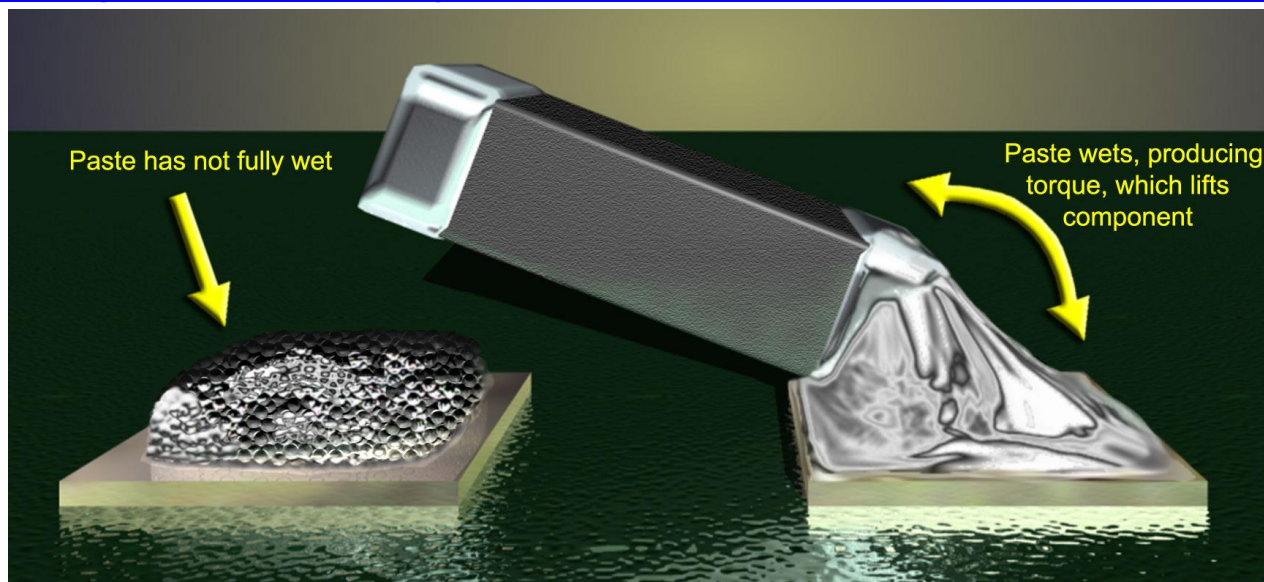
Solder paste

- For surface mount, use solder paste or cream
- Small balls of solder (around 30 μm) in a liquid flux
- Melts into liquid during reflow and then solidifies



Notes on SMD soldering

- Surface tension forces of molten solder often exceed the weight of the component
- Leads to problems such as “tomb-stoning”
- http://www.youtube.com/watch?v=o_SwxI2KTys



Wave soldering

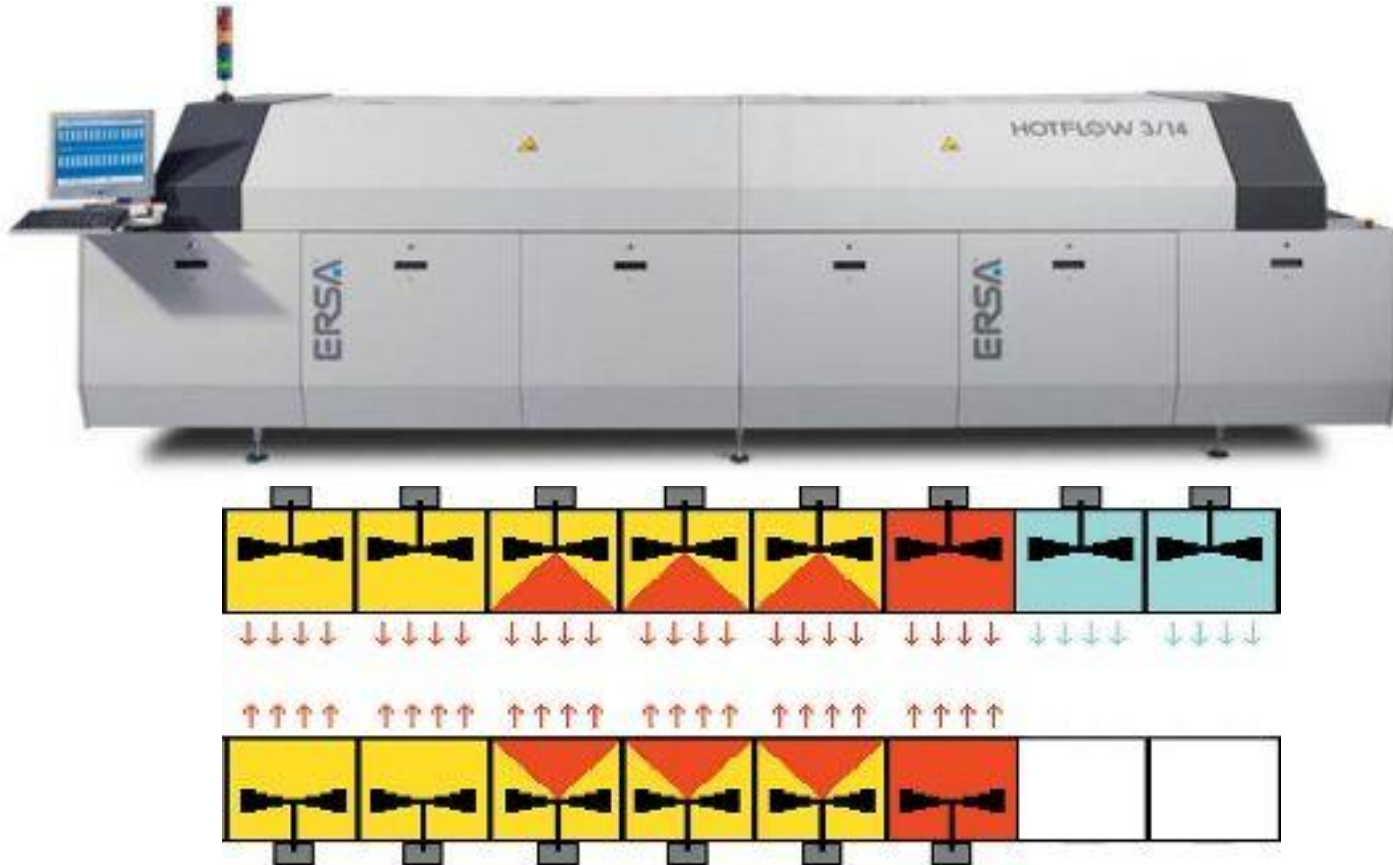
- Pass boards over a wave of molten solder on a conveyer system



- <http://www.youtube.com/watch?v=CH2tE9Wct4U>

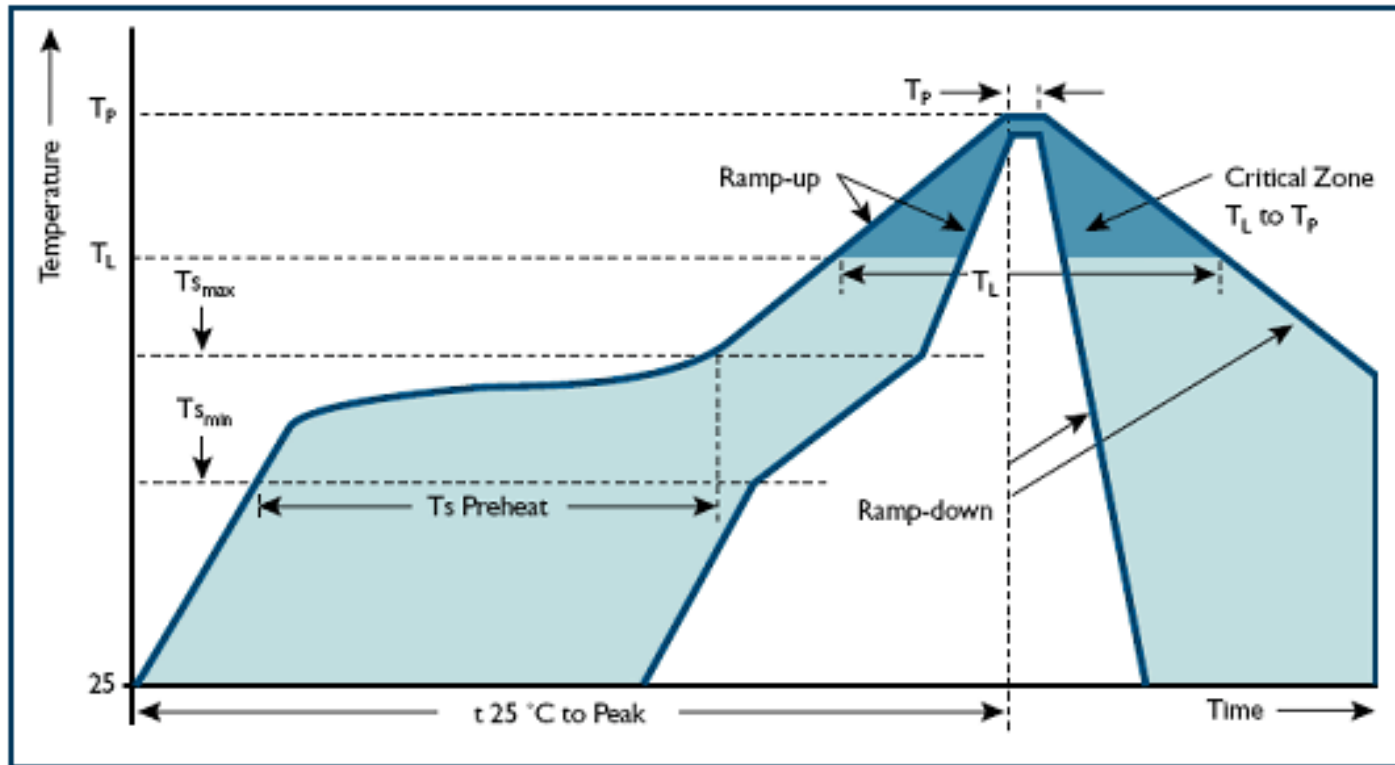
Infrared reflow

- Multi-zone heaters, boards pass by on conveyer belt



Typical reflow profile

- Times and temperatures are critical
- Taken from NXP datasheet...



Assembly: Single-sided SMD only

- Reflow
 - Apply solder paste
 - Place SMD components
 - Preheat board (bake out moisture)
 - Reflow solder
- Wave
 - Deposit adhesive
 - Place SMD components
 - Cure adhesive
 - Flux spray, wave solder

Assembly: Double-sided SMD only

- Reflow
 - Apply solder paste to side #1
 - Place SMD components side #1
 - Preheat board (bake out moisture)
 - Reflow solder
 - Apply solder paste to side #2
 - Place SMT components side #2
 - Preheat board (bake out moisture)
 - Reflow solder
 - Clean

Summary

- PCB fabrication processes
- Population
- Soldering

