THE ART AND SCIENCE OF PCB DESIGN

IAP 2025

Lecture 09 - FABRICATION

How boards are made

Outline

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- Introduction
- PCB Layer Stackup
- Population
- Summary

Layer Types

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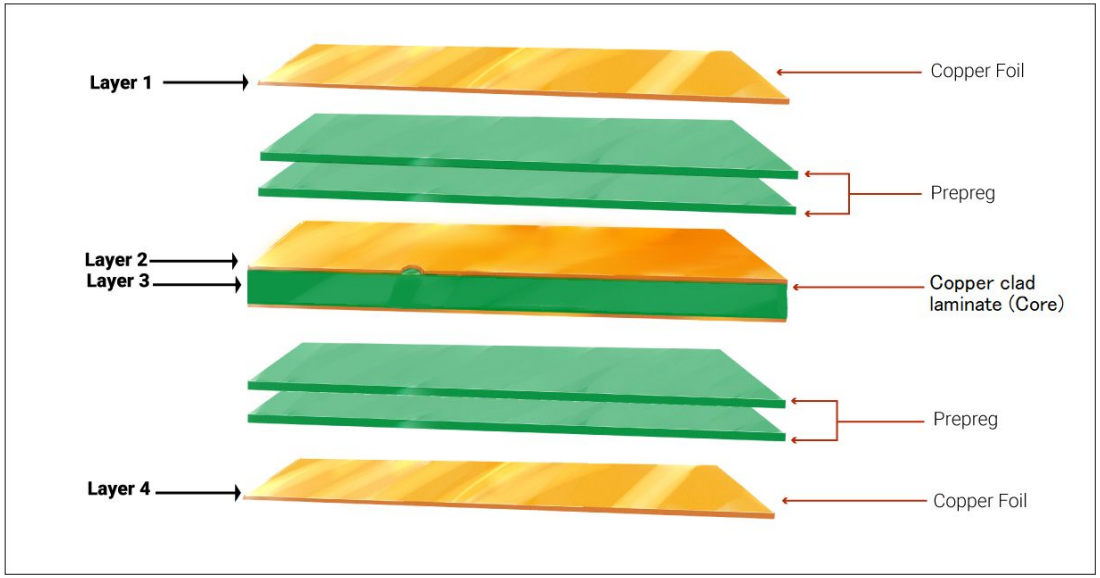
Signal Layers
Power Plane
Ground Plane
Dielectric Layers
Surface Finish
Adhesive Layers



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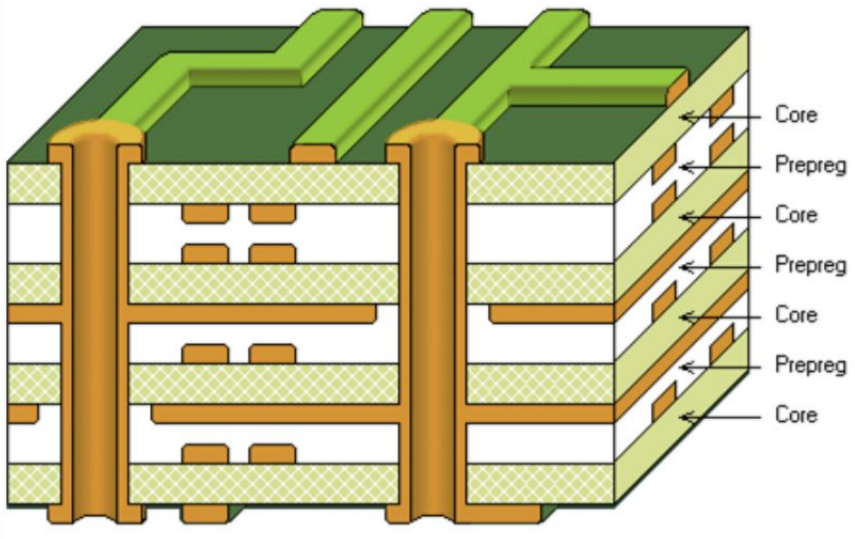
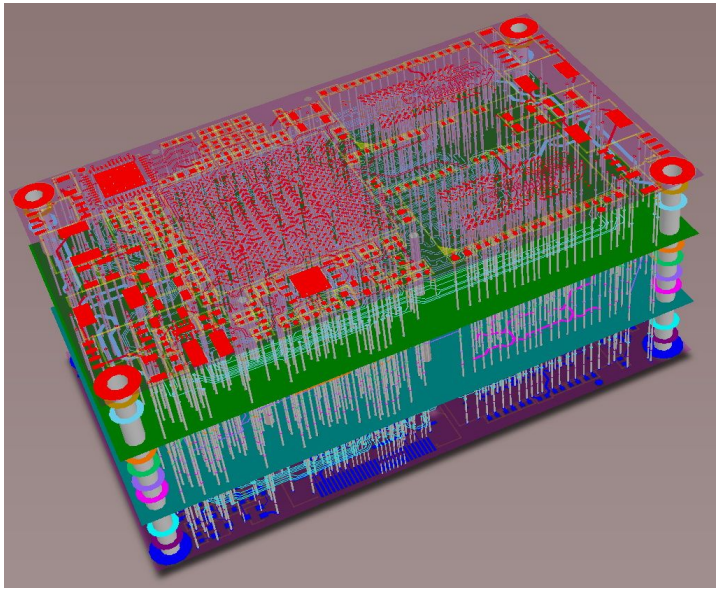


Signal Layers

- **Where you put traces**



pcbasic.com

Ground and Power Planes

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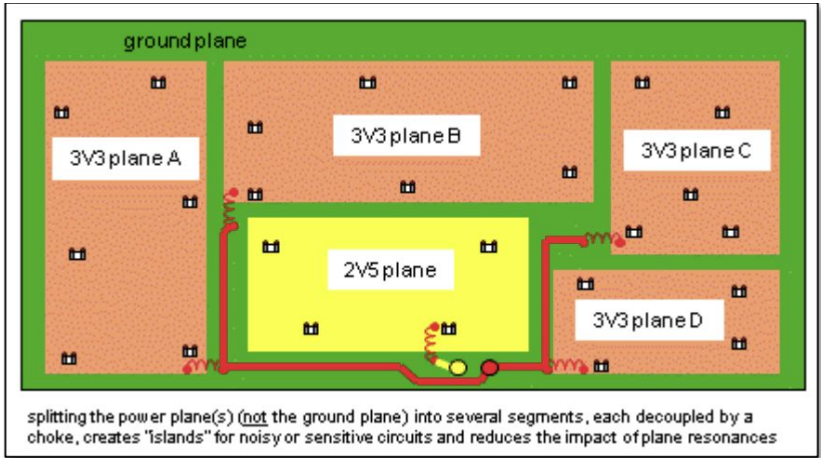
- **Reduces traces for power and ground rails**
- **Just send a via to connect**



splitting the power plane(s) (not the ground plane) into several segments, each decoupled by a choke, creates "islands" for noisy or sensitive circuits and reduces the impact of plane resonances

Core & Pre-preg

Insulating Layers

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Core

- FR4 w/ copper on both sides
- Typically thicker
- Specified thickness

Pre-preg

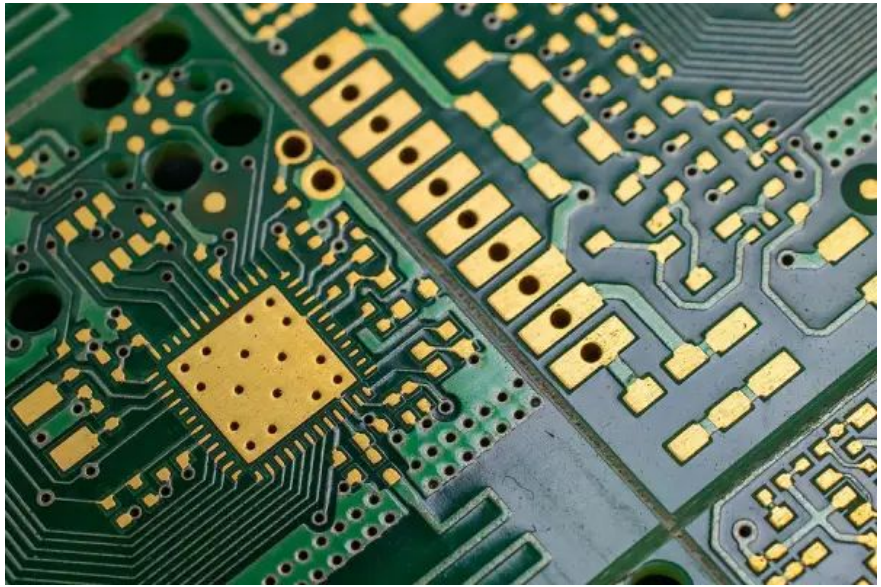
- Uncured FR4
- Glues layers together
- Thickness depends on layers around it

These have different dielectric constants

Surface Finish

Oooo shiny!

- Conductive Material
- What you solder to
- Protects copper from oxidation
- Improves solder-ability (as opposed to copper)



www.mokotechnology.com

Surface Finish

The many types

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Hot Air Solder Level (HASL)	Most common & inexpensive, basically just molten solder, better for larger components
Plated Gold	Expensive but very durable. Harder to solder
Organic Solderability Preservatives (OSP)	Inexpensive but not very durable.
Immersion Silver	Moderate price and lifespan. Thin layer of silver. Good for Fine Pitch Technology. Prone to tarnish
Immersion Tin	Reasonable cost. Prone to tarnish and can react with copper. Great for Fine Pitch Technology.

Surface Finish

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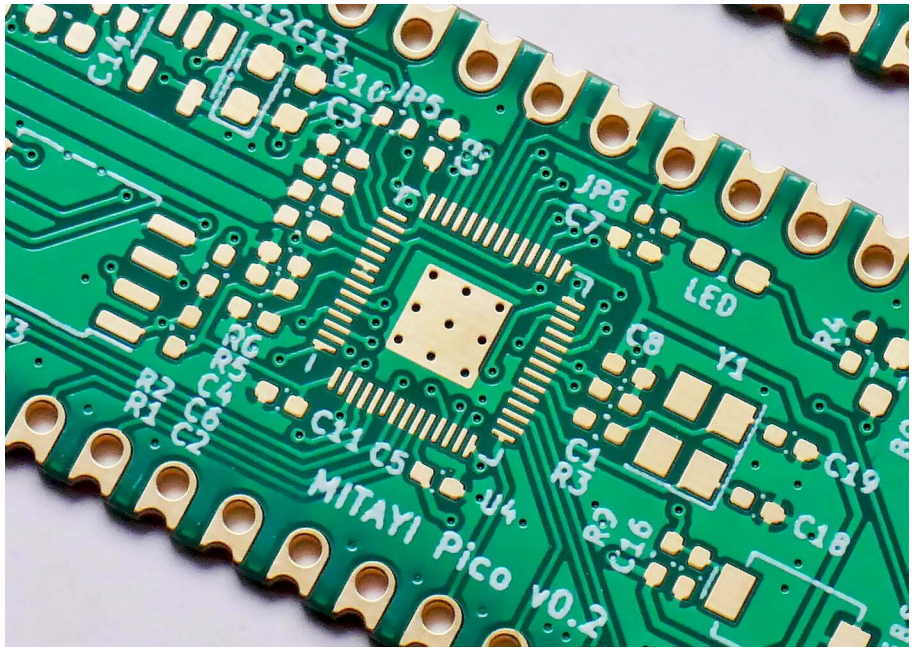
Electroless Nickel Immersion Gold (ENIG)	Most common. Thick layer of nickel covered by a thin layer of gold. Durable but expensive.
Electrolytic Nickel Gold	Expensive. Electrolytic nickel covered by gold. Great performance and small components, lasts long.
Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG)	Long shelf life, 3 layers (nickel, palladium, gold). Expensive.
Mixed Surface Finish	Most common combos: • ENIG + OSP • ENEG + ENIG • ENEG + HASL • ENIG + HASL

Soldermask

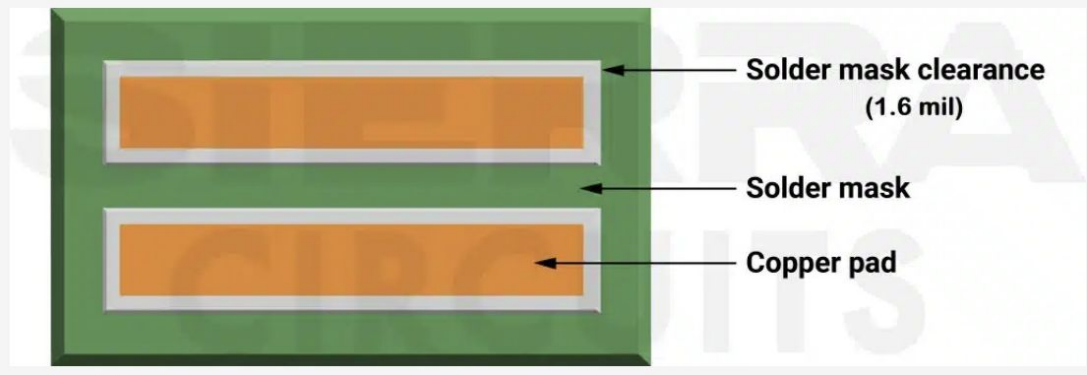
Green stuff 🟢 ✅ 🦖 💚 🤢 🐉 🐍 🍀 ☘️

- Insulation
- Protects from unwanted connections
- Protects from environmental contamination

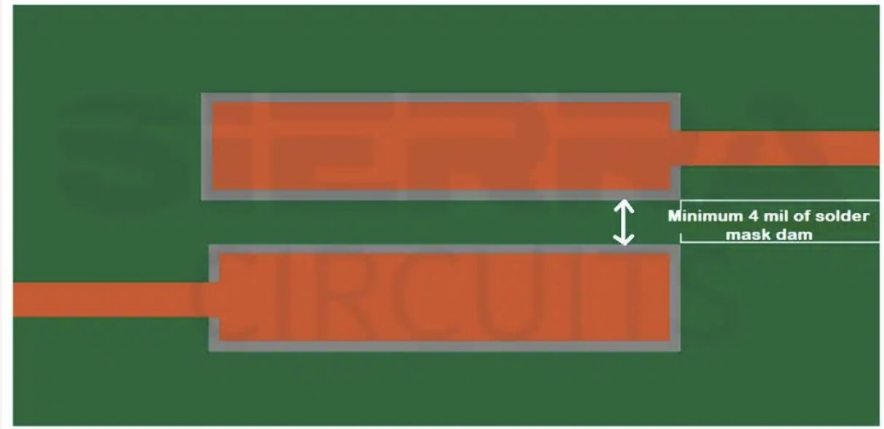


pcbways.pages.dev

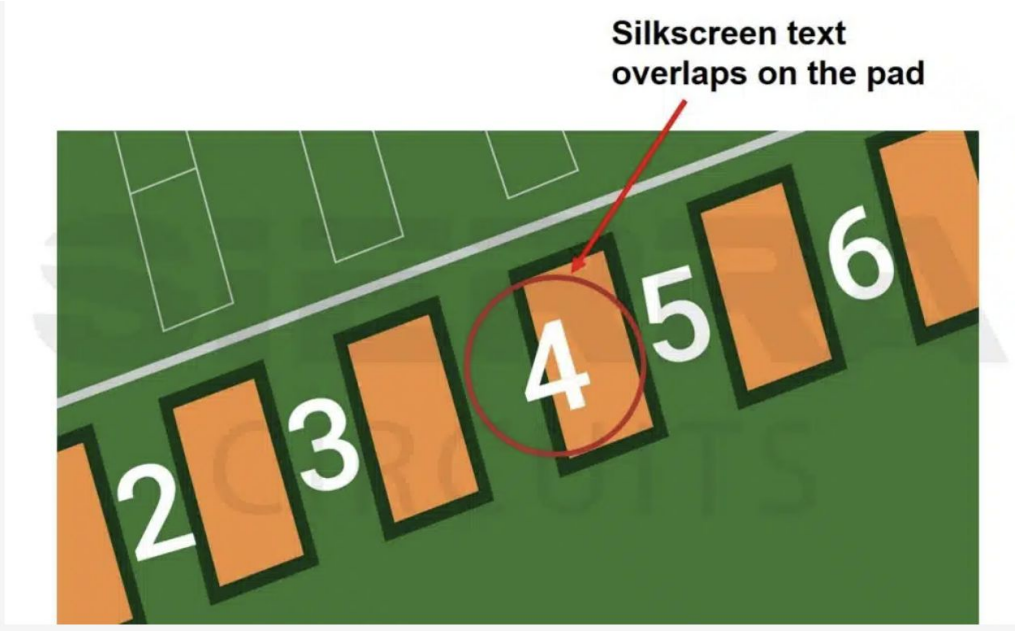
Soldermask



protoexpress.com



Soldermask



protoexpress.com

Population

Machine vs. Person

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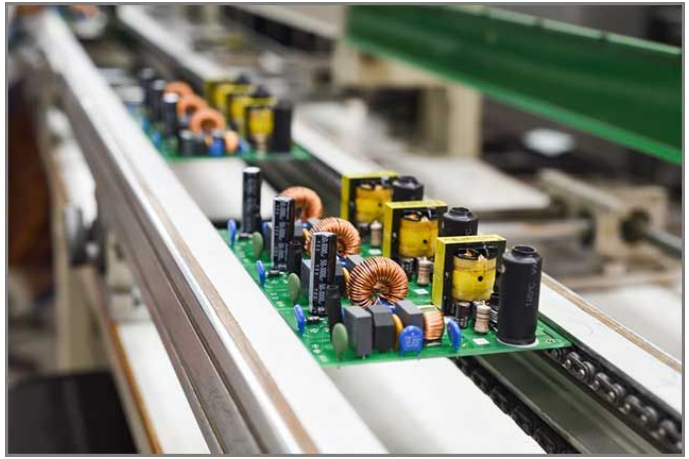
So many ways to solder!

- **Human labor is costly & time consuming**
- **Humans don't want to inhale flux fumes (usually)**
- **Machines can solder faster & cheaper, but have some limitations**



www.ourpcb.com

Pick and Place Machine

- **This machine automatically places components on a board**
- **Typically just SMT**

rushpcbs.com

Reflow Soldering

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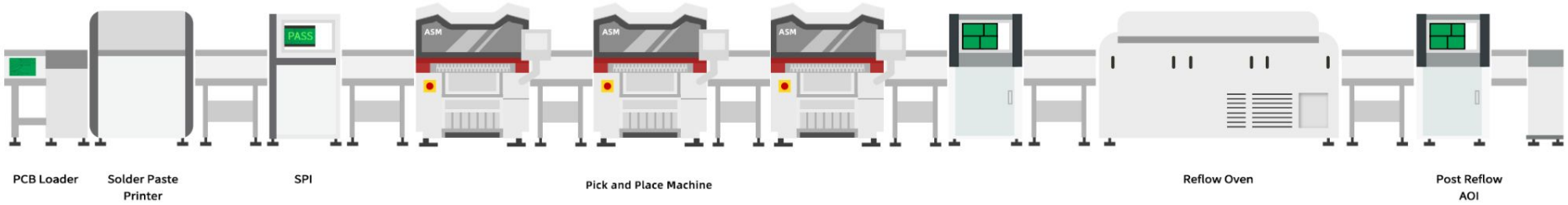
- Process of heating solder paste to bind components
- Quickly adheres large number of components to a board

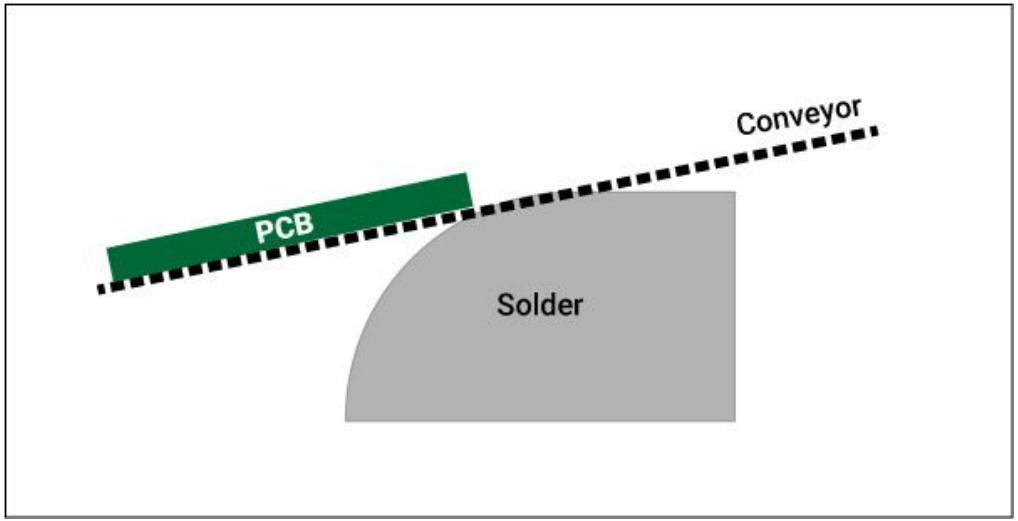


nextpcb.com

Wave Soldering

🌊🌊🌊🌊🌊

- **Machine soldering method for through-hole components**



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Hand-Soldering Techniques

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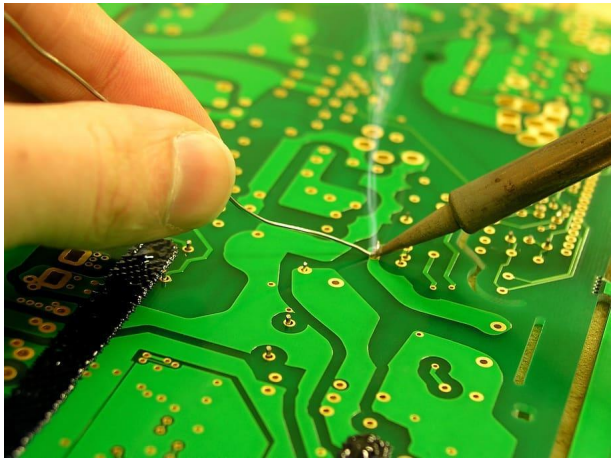
So many ways to solder!

- **Stencil & Reflow**
- **Paste vs. Wire Solder**
- **Iron**
- **Hot Air**



Iron & Wire Soldering

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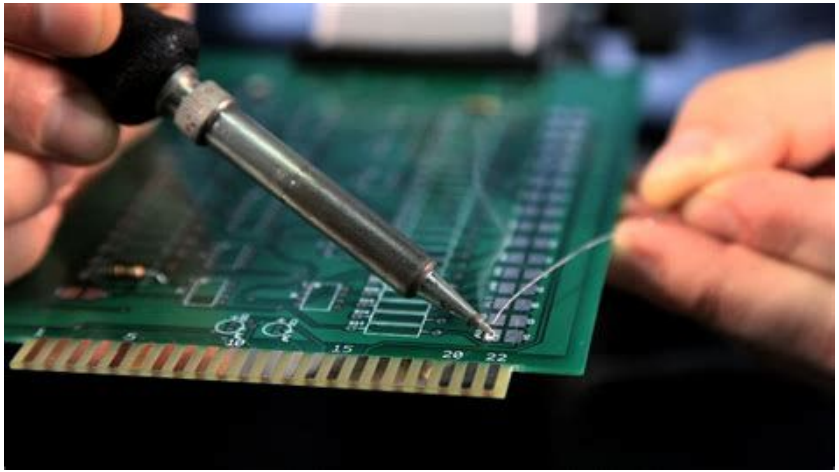
- Most through holes are soldered this way
- Easier on larger SMD components
- Soldering iron tips can be changed
- Iron tips degrade – tin to avoid rust



uvmfablab.net

Iron & Wire Soldering

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components101.com

forum.allaboutcircuits.com

Soldering Iron Maintenance

Tinning

Tip Cleaning Sponge

Tip Cleaning Copper Wool

www.electronicsandyou.com

www.retrotechlab.com

PCB Stenciling

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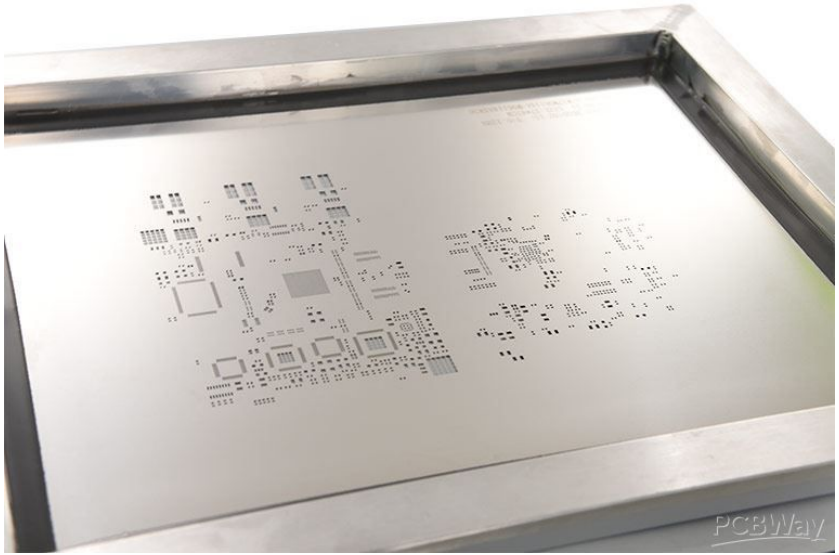
- Align PCB with the stencil
- Cover with solder paste
- Place components
- Reheat

fctsolder.com



pcbway.com

Reflow

www.bigmessowires.com

www.mechatronic-systems.com

Hot Air Soldering

- For individual components
- Syringe solder paste instead of tub

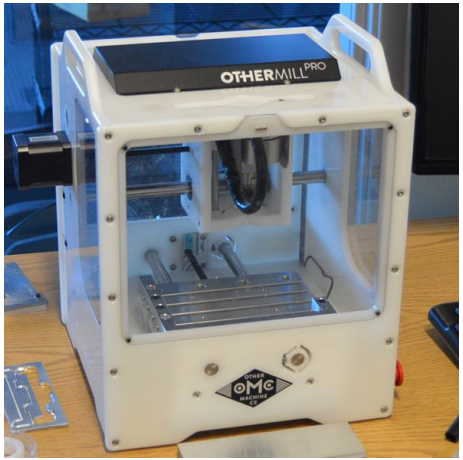
www.amazon.co.uk

www.conrad.com

Something super cool!

The OtherMill

- **Small CNC PCB Mill**
- **For personal use!**
- **There are some on campus for students to use!**



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Questions

Announcements

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- Complete Lecture Quiz 09
- If you have not completed any lab check-offs (Lab 01 through 05) please come to office hours
- Be prepared for this week's lab which will consist of assembling and soldering your FM radio project board (staff design)
- IAP course evaluation period has begun (closes Friday). Your feedback is greatly appreciated!