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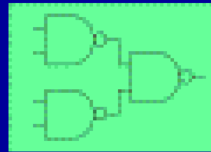

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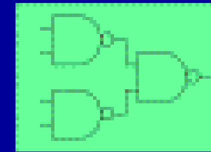


Electronics in High Energy Physics

Winter Term: Introduction to Electronics in HEP

Printed Circuit Boards (PCB) and Hybrids: Part 2

PCB Production at CERN

Rui De Oliveira / TS-DEM

3 February 2005

A. PCB Process

B. Different Technologies

C. PCB in Detail

D. Helpful Tables

A. PCB Process

- Photo Plotter (creating the films)
- Image Transfer (internal layers)
- Etching & Stripping
- Optical Control
- Pressing
- Drilling (different drilling)
- Metallization
- Image Transfer (external layers)
- Solder Mask, Legend Ink & Milling
- Nickel / Gold Plating
- Electrical Test

Summary of PCB Process

Base material

Lamination of photoresist

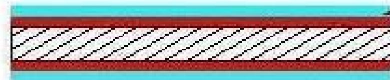
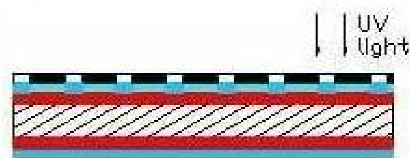
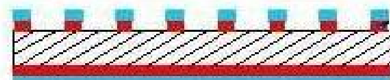


Image transfer (internal layers)



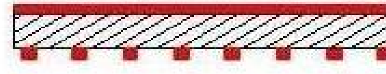
Development

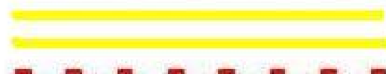
Etching



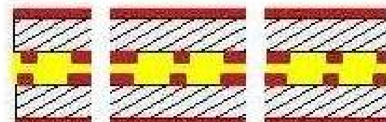
Stripping

Pressing





Drilling



Metallization

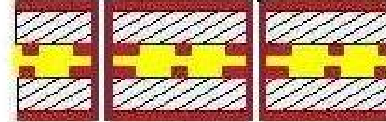


Image transfer (external layers)

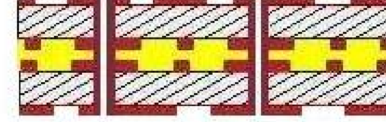


Photo Plotter (creating the films)

- Equipment : Barco BG7300
- Max size : 500 mm x 600 mm
- Resolution : 10000 DPI
- Minimum line width and spacing: 20um
- Film based on Polyester 100um thick
- Type of files : DPF , DXF, GDS2, GBR
- Software : Cadence, Pcad

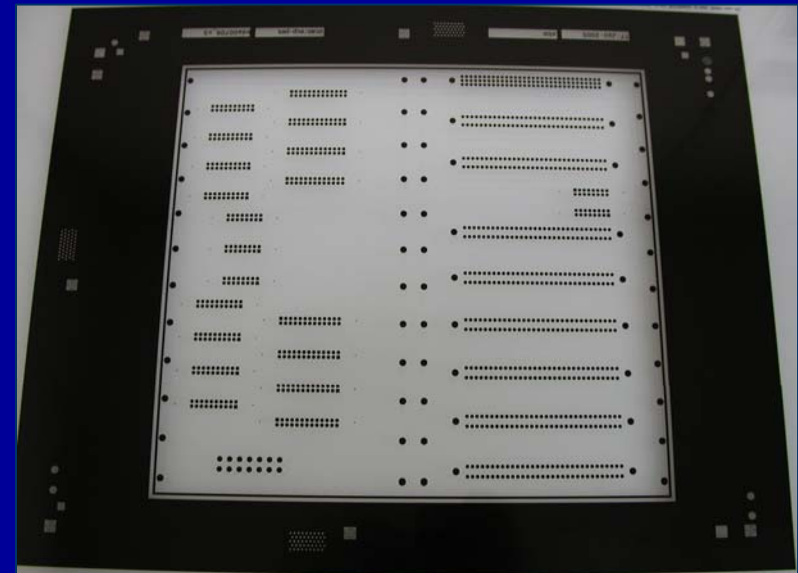


Image Transfer (internal layers)

-Equipment: Dupont hot roll laminators
-Solid resist 15 um to 100 um thick

-Other methods: vacuum laminators
liquid resist

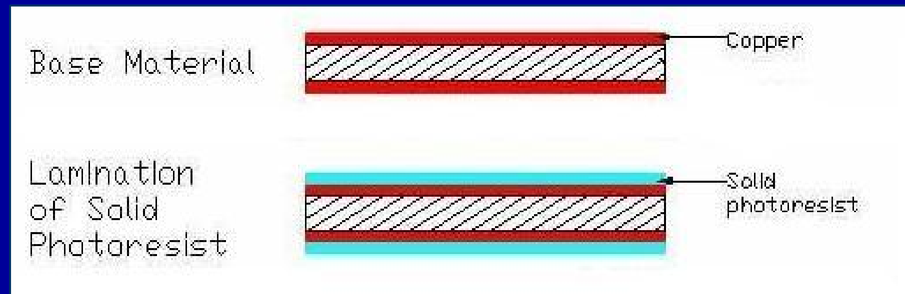
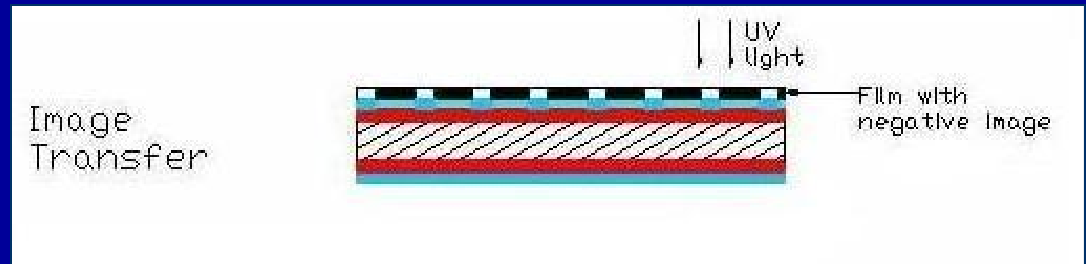


Image Transfer (internal layers)



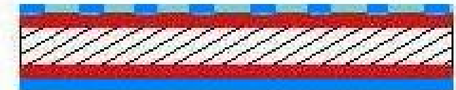
- Equipment: Dupont PC130
- 700mm x 800mm max board size
-Simultaneously expose top and bottom

-Other types: collimated lamps
Direct imaging
Automatic alignment

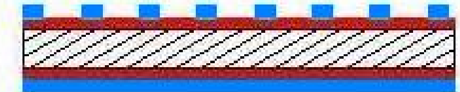
Development (internal layers)

- Equipment: RESCO developing machine
- Spray development (aqueous)
- board width max: 800mm
- board length : no limit
- board thickness : 6mm max

Image Transfer

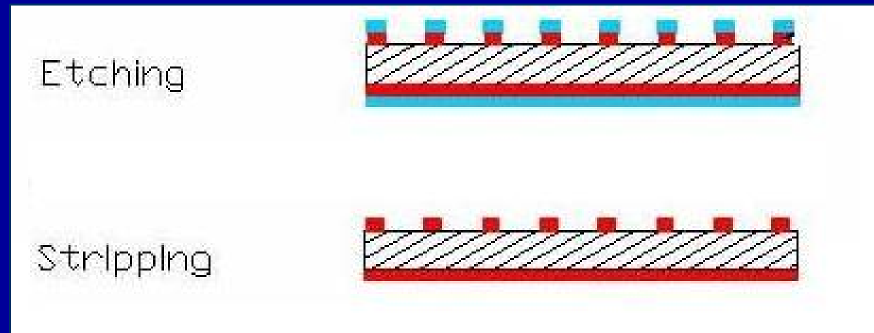


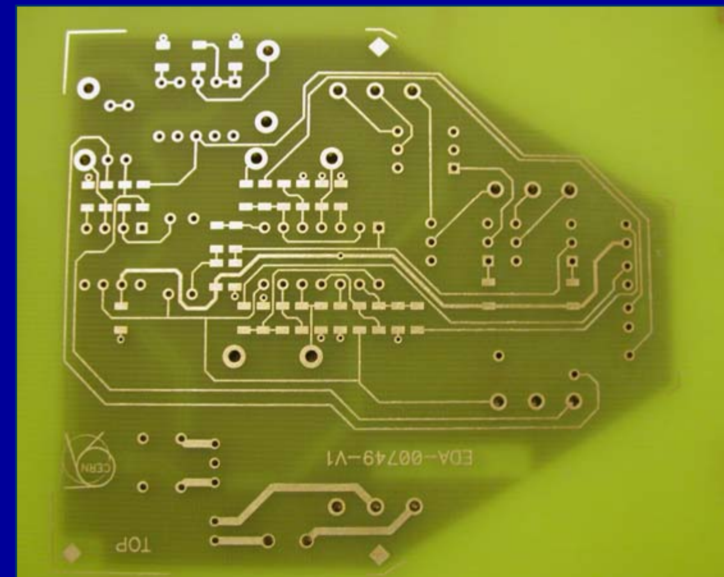
Photoresist Development



Etching and Stripping

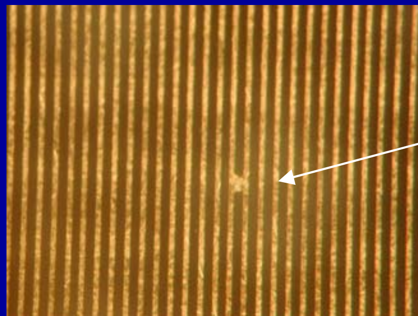
- Equipment: ADAM PILL spray etcher
- Etchent : ferric perchloride
- Etchable materials : Cu, Steel , Al, Ni Stainless steel
- Board width max : 800 mm
- Board length : no limit



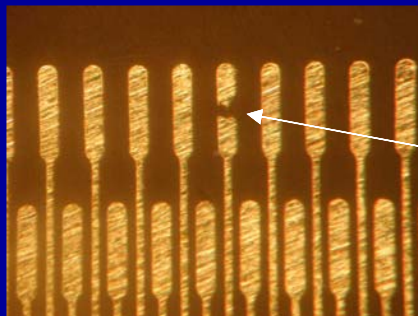


Optical Verification (AOI)

- Equipment: Orbotech PC14 micro
- Compare the scanned pattern with a file or with a “golden board”
- Minimum track or space 20um
- Minimum detectable defect around 5 um (pixel 2.5um)
- Cannot detect hole plating defect



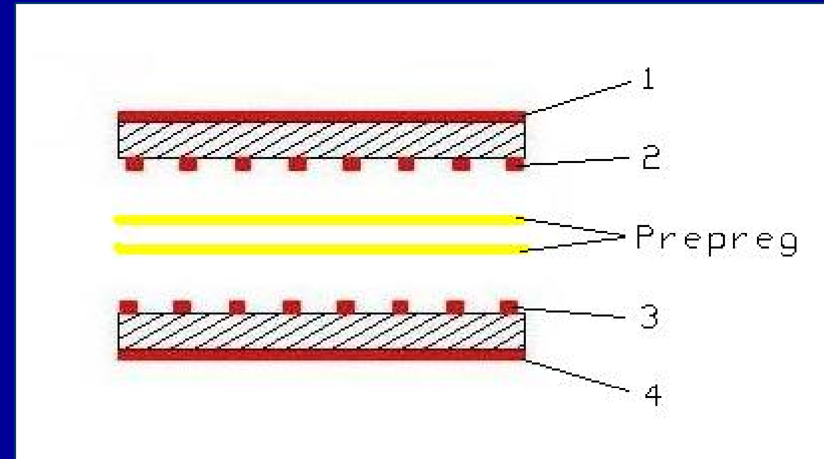
Short circuit



Open
Bonding pad

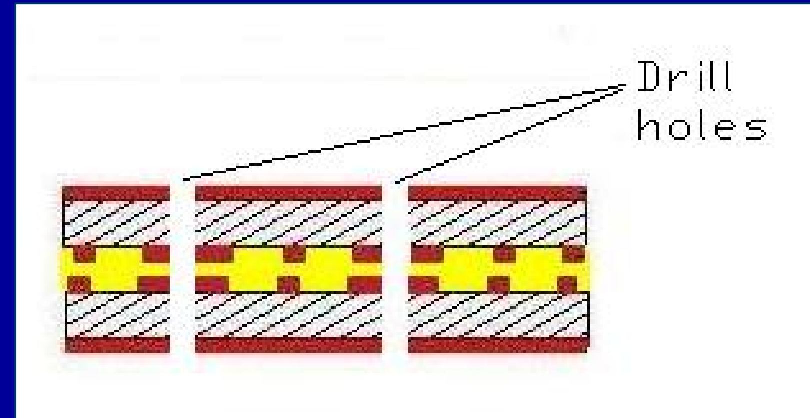
Pressing

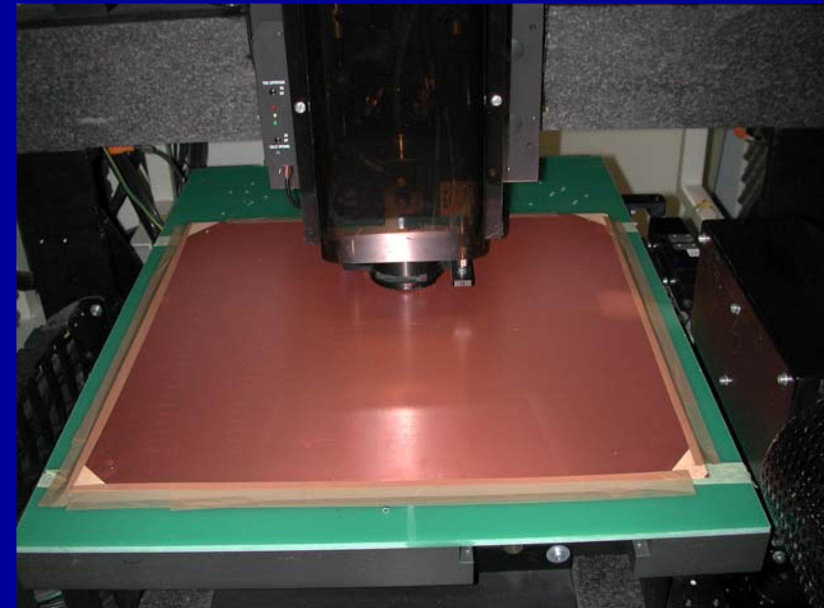
- Equipment : Bieffebi 4 daylight Isostatic press
- Max number of layers: 40…
- Typ pressure : 20 KG/cm2
  50 Tons for a 50cm x 50cm board
- Typ temp : 180 deg C
- Typ vacuum : 0.01 Bar



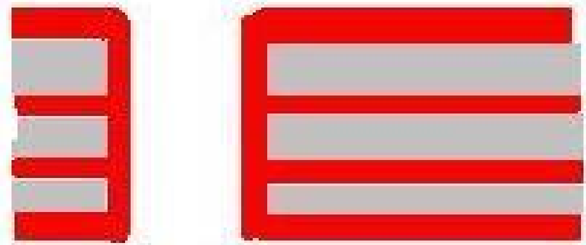
Drilling

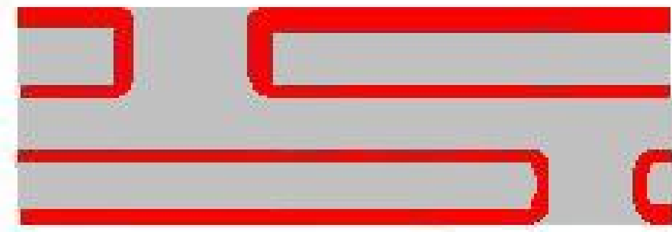
-Equipment	: Pluritec Minima
-Tools:	: Tungsten carbide
-Min diameter	: 0.15mm
-Max speed	: 150000 rpm
-Board size max	: 600mm x 700mm
-Blind drilling	

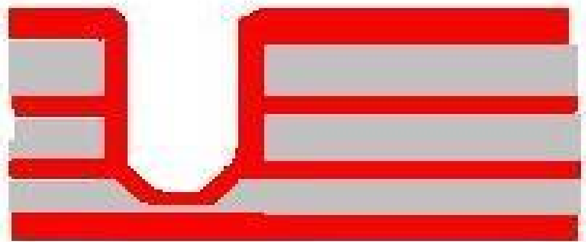


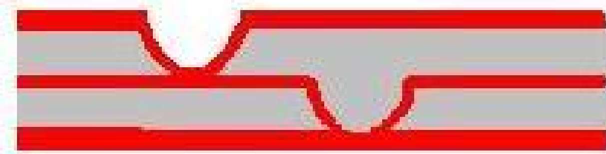


Different Drillings









Laser , plasma, chemical

Metallisation

-Equipment : different baths +
handling robot
-Steps 1: desmearing (cleaning)
2: chemical copper deposition
3: electrolytic copper
-Copper thickness from 5 um to 100um
-Panel plating
-Daily controlled of baths

-Other ways: spray inline machines
Ultrasonic baths
Pulsed electroplating
Micro via filling baths

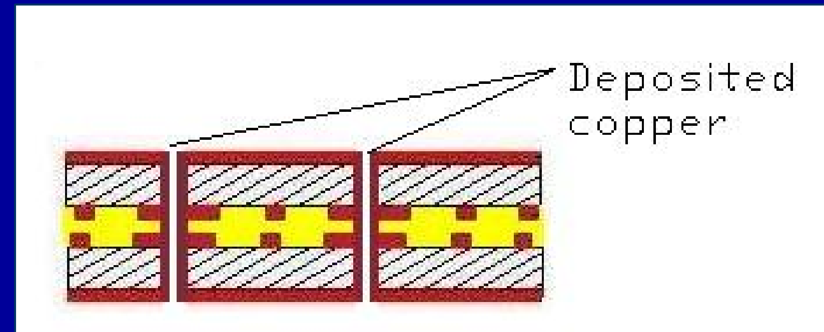
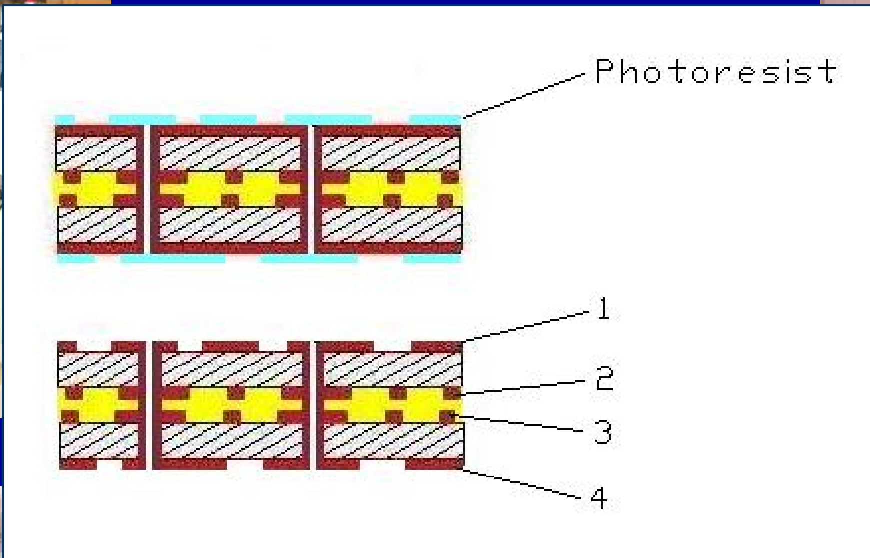
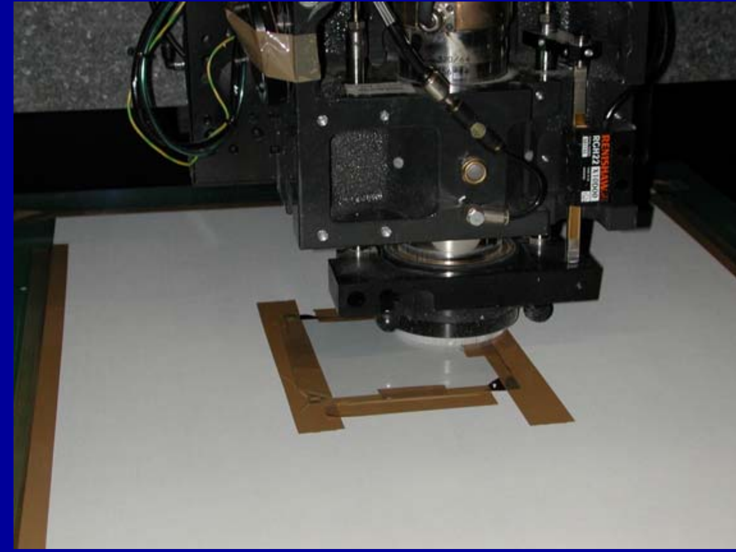


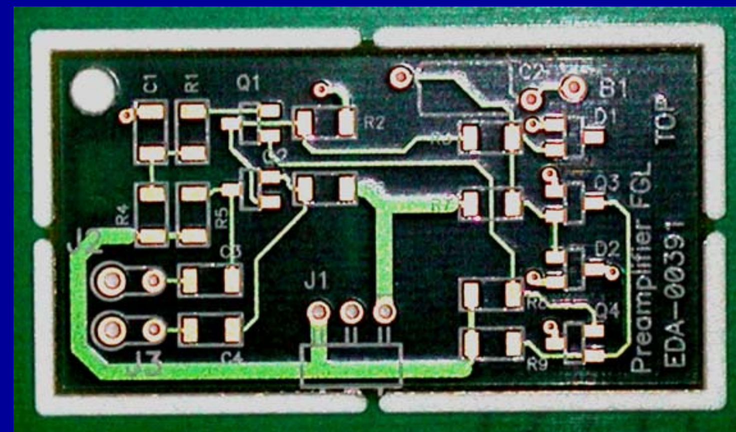
Image Transfer (external layers)



Solder Mask, Legend Ink & Milling



- Silk screen printing for solder mask and legend ink
- Milling (tungsten carbide tools)
  Z-axis control of the tool



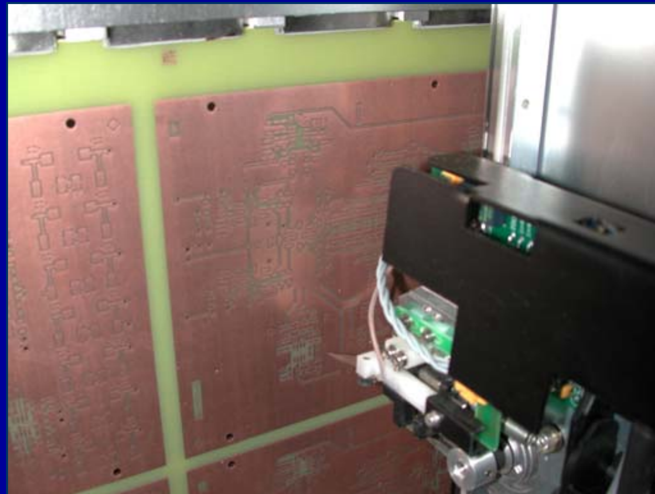
Nickel / Gold Plating

- Why?: To Protect copper from oxidation
  To be able to sold with tin/lead solder
  To be able to Bond with Aluminum wires

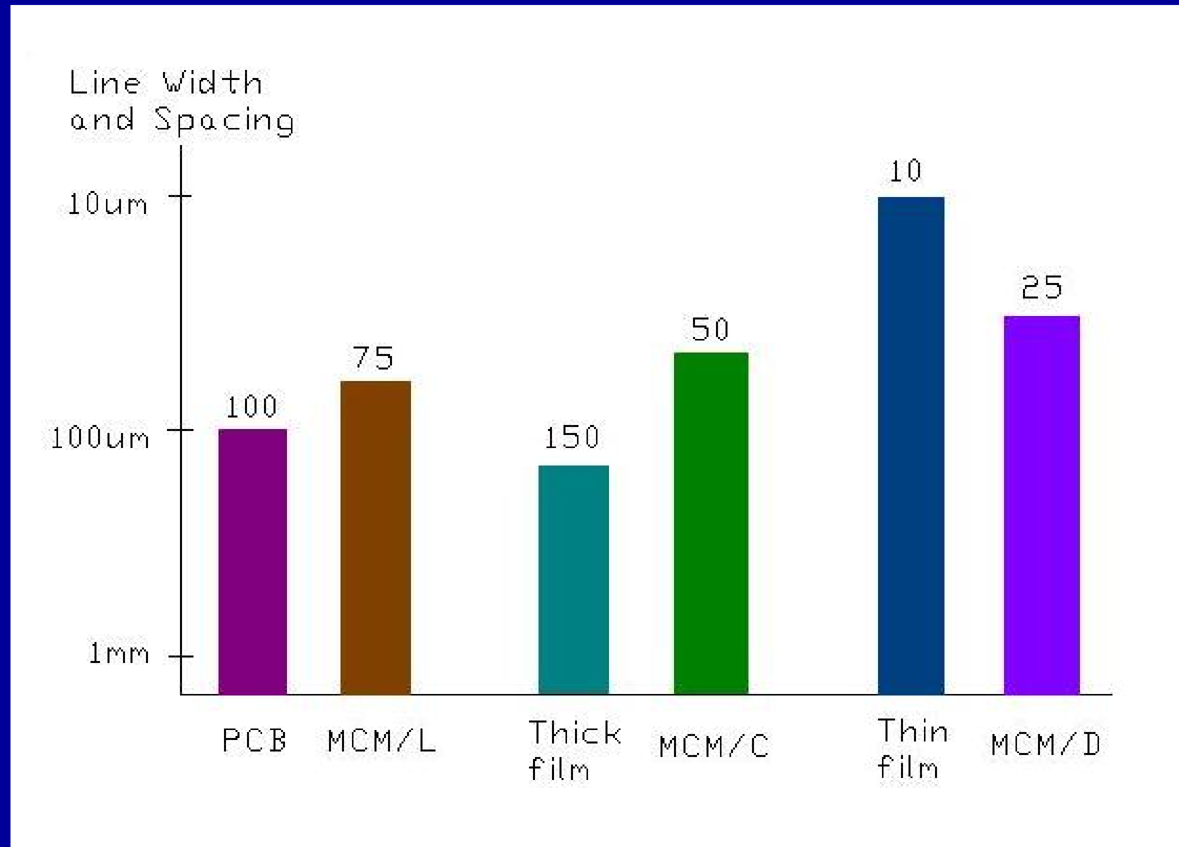
- Immersion Ni/Au (Chemical bath)
- 5um NI + 0.1um Au
- Wedge Aluminum compatible
- Reflow, wave or iron soldering
- No Lead

Electrical test

- Equipment : Mania Barco Speedy 580
- Flying probe tester
- Compare netlist from the design to the connections on the board
- 150um Minimum pattern
- Rigid boards or flex



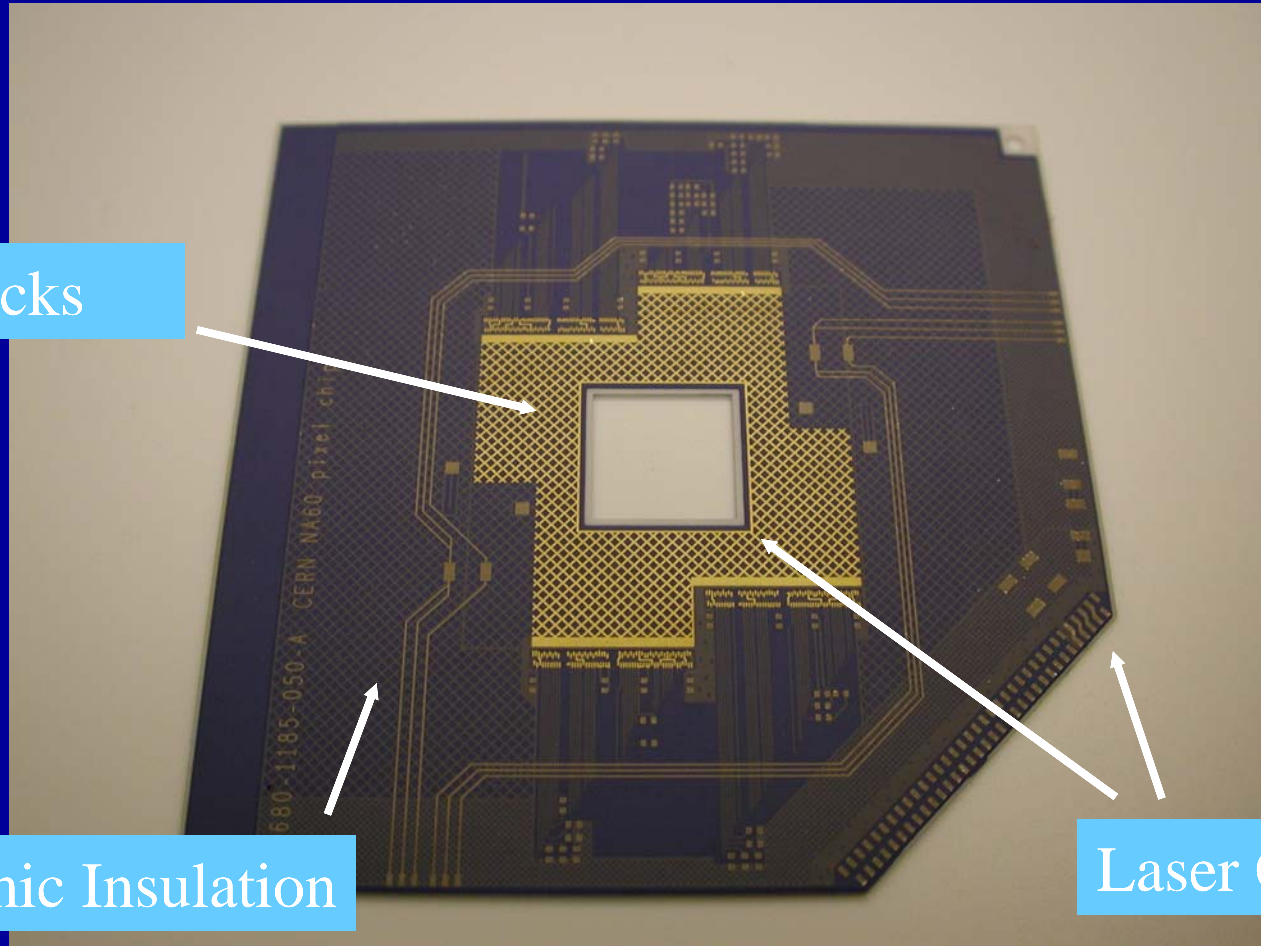
B. Different Technologies



MCM: Multi chip module

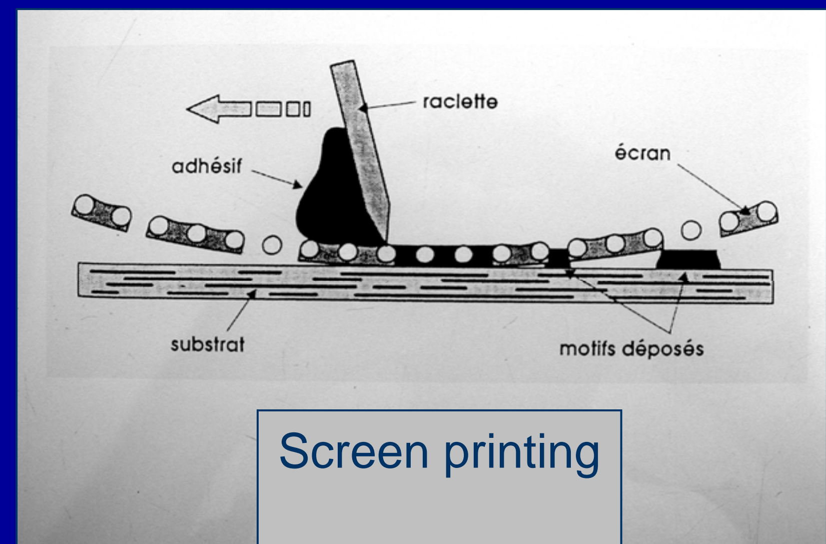
L: Laminated
C: Ceramic
D: Deposited

Thick Film - MCM / C



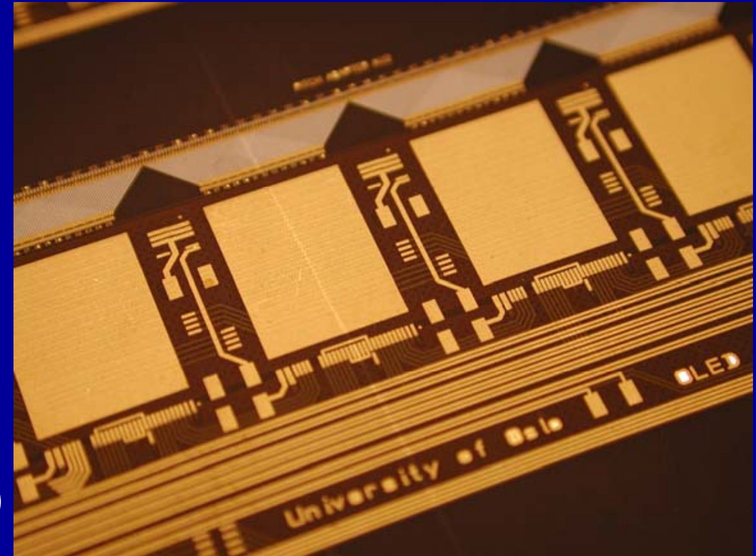
Thick Film - MCM / C

- Equipment : screen printing machines
  : firing oven
  : collimated UV lamp
  : gold etching machine
  : 1000 Class clean room
- Conductor Materials : Au,Ag,PtAu,PdAg
- Dielectric materials : mainly Al2O3
- Substrates : AL2O3, Beo, Aln, stainless steel
- Minimum track width: 100um screen printed
  : 50um etched
- Minimum via : 200um screen printed
  : 75um etched
- Really good long term reliability!



Screen printing

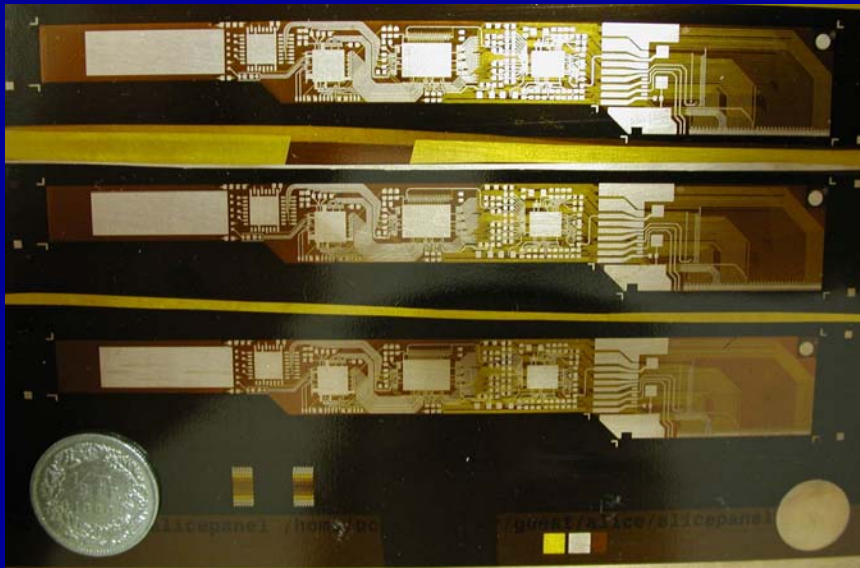
Thin Film - MCM / D

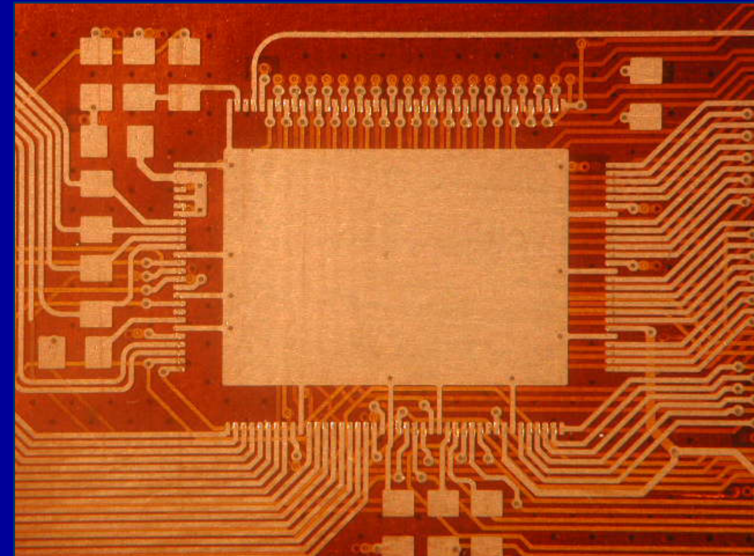


- Equipment	: Spinner
	: Sputtering machine
	: Collimated UV lamp
	: Class 100 clean room
- Conductor material	: AL , Cu (1.5 to 15um)
- Dielectric material	: Polyimide (5 to 30um)
- Minimum track	: 10um
- Minimum via hole	: 25um
- Substrates	: Al , Al2O3, Aln, Carbon/Carbon, copper Pyrolitic graphite, glass

PCB - MCM / L

- same process as PCB but : sequential process
  : laser , plasma or Chemical patterned via (50 to 100 um)
  : min line 50 to 75um

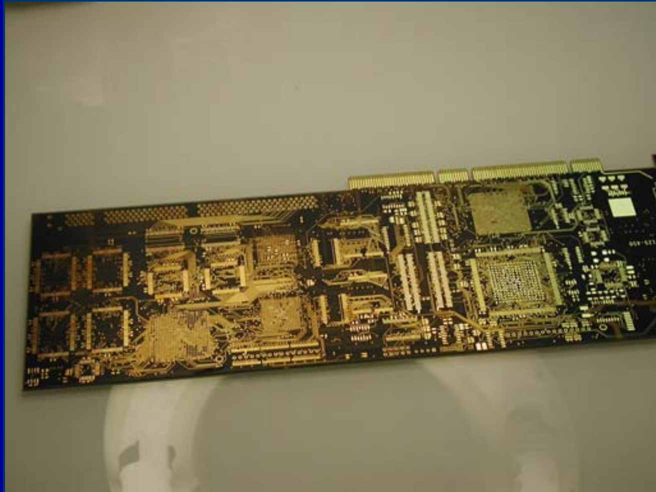




C. PCB in Detail

- Different Structures
- Different Materials
- Different Platings
- Embedded Components

Different PCB Structures



Rigid

Flex

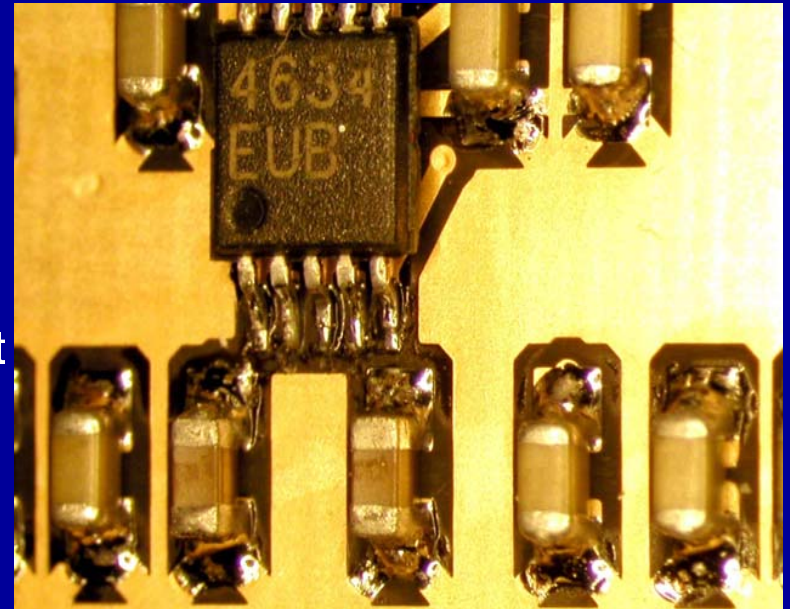
Flex-rigid

Different Materials For PCB

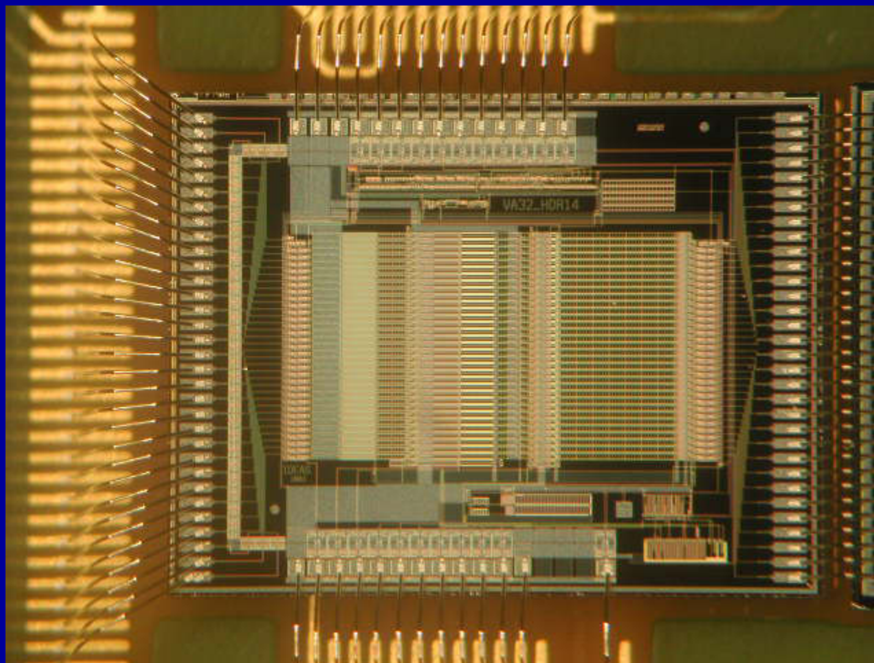
- Dielectric matrix: FR4, G10, Teflon, Polyimide, polyethylene, halogen free, cyanate ester.
- Dielectric fiber: Glass, Kevlar
- Conductors: Copper
- Built in Heat Sink: Cu/Invar/Cu, Cu, Al, Carbon

Different Platings

- Ni/Au for reflow and aluminum wedge bonding
- Tin lead (HAL) for reflow
- Ni/thick AU for gold ball bonding
- Au/Cobalt for direct board insertion connectors
- Ni/Au for press fit
- Chemical tin or organic passivation for low cost



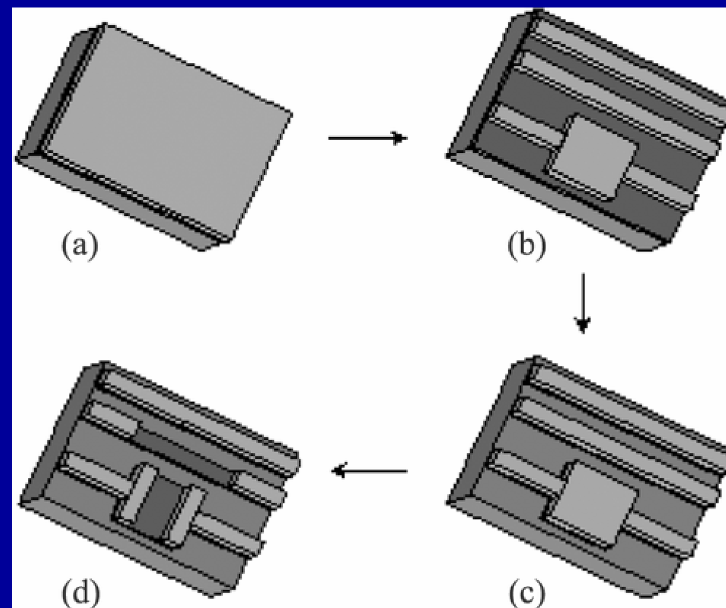
SMD soldering



Wire Bonding

Embedded Components

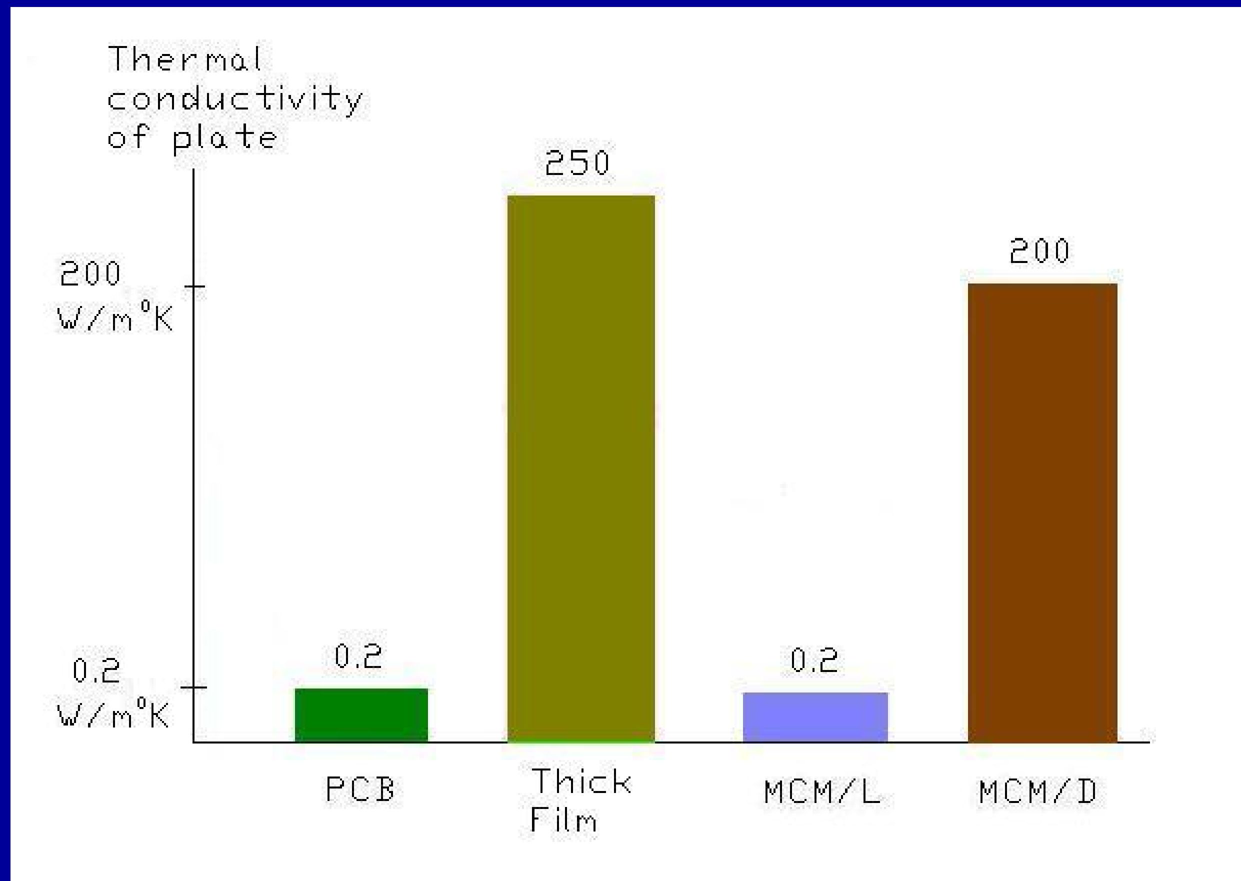
- Screen printed resistors
- Etchable resistive layers (Omega ply)
- High Epsilon dielectric materials (to create capacitors)
- New trend: active silicon (under development)



D. Helpful Tables

- Thermal Performance
- Resolution
- Signal Speed
- Degassing
- Price

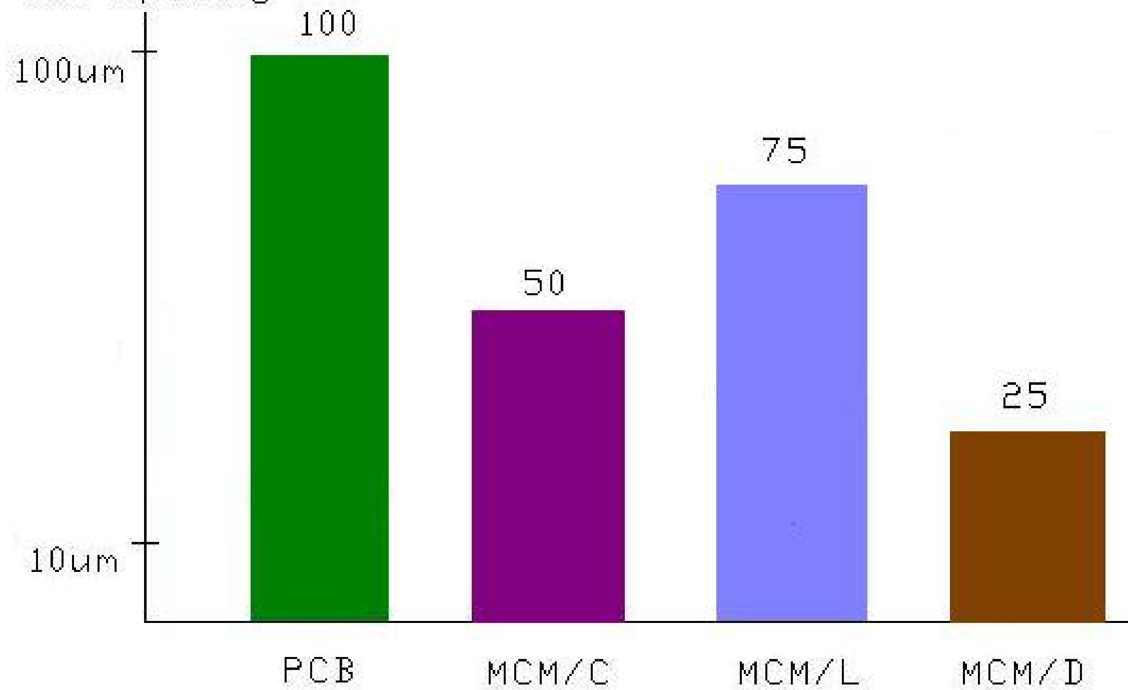
Thermal Performance



Out of this graph:

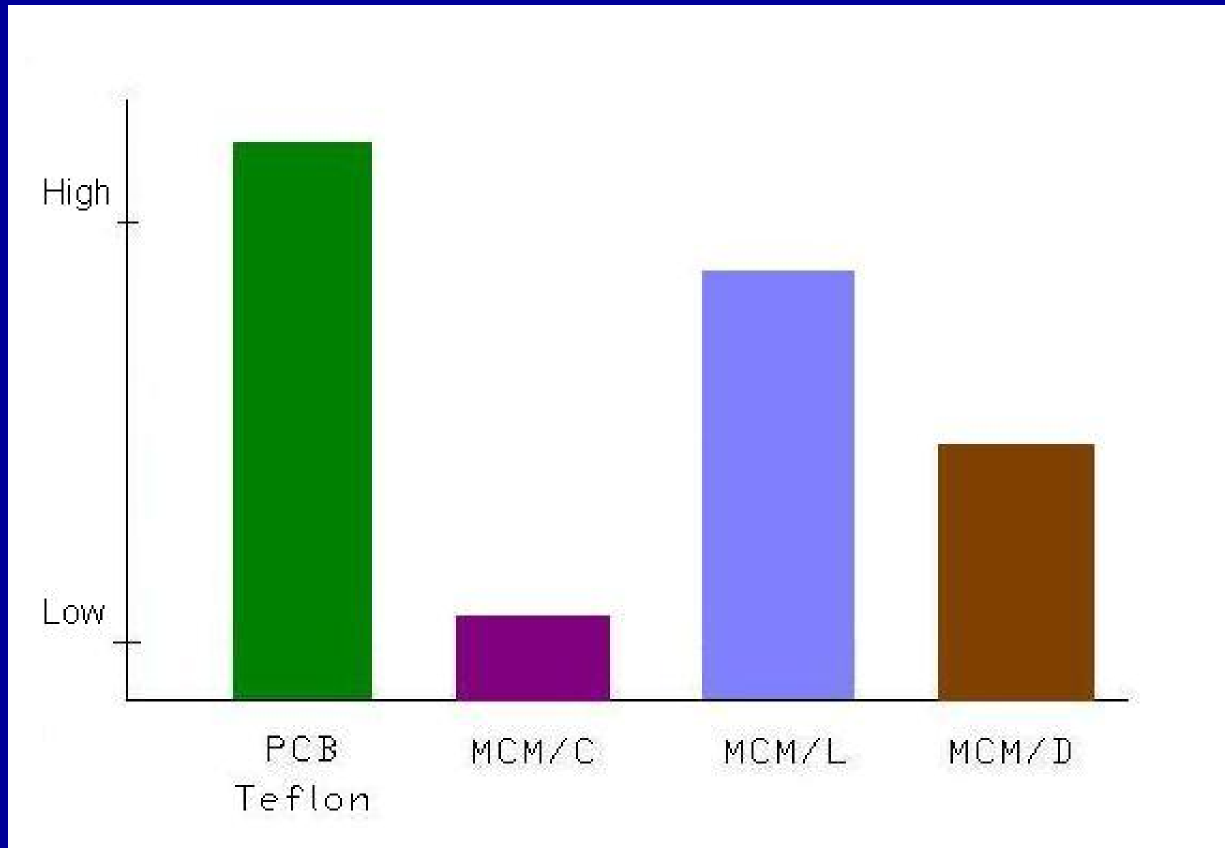
PCB with metallic core
MCM/L with substrate

Resolution



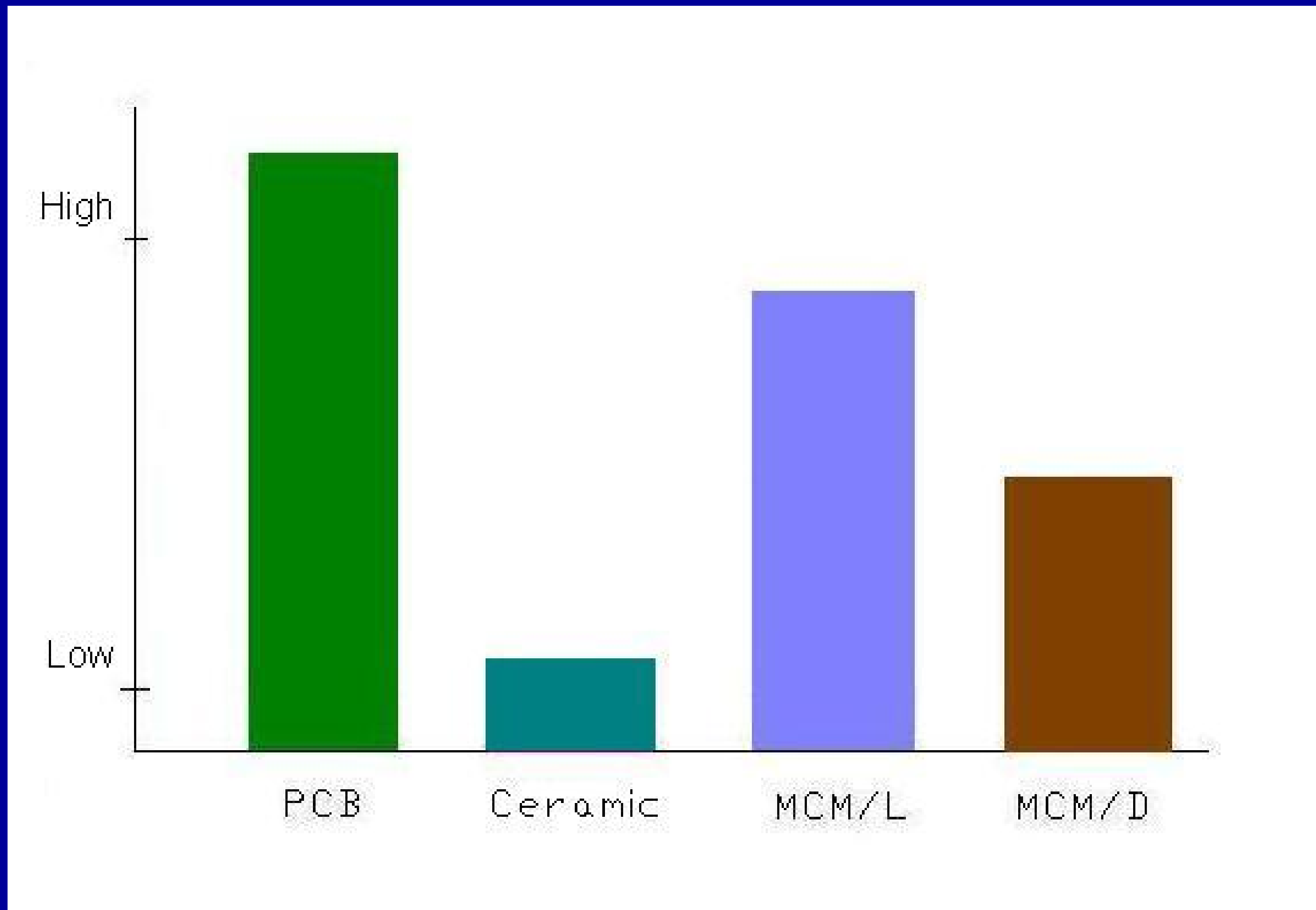
-Thin film: down to 5um
Single layer

Signal Speed

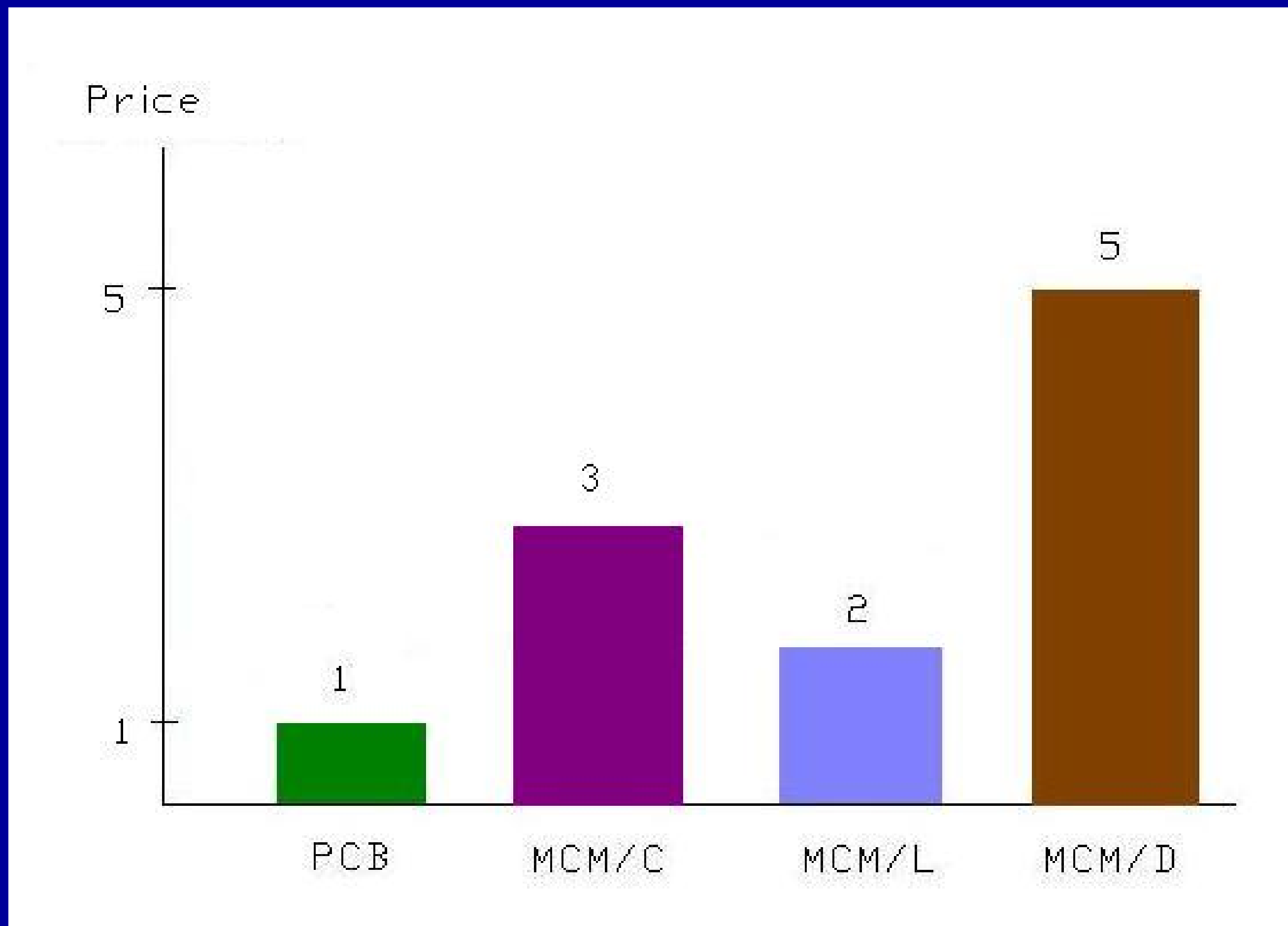


-Related to layout
-Related to materials

Degassing



Price



-Materials
-Clean rooms
-Processes
-Skilled technicians

Conclusions

- Printed circuit board production is a challenge because of its complexity.
- Multiple technologies and skills - mechanics, (drilling), photolithography (exposure), and wet processing, engineering and above all environmental aspects - are needed to produce PCBs with high qualities and yields.

Bibliography

- Integrated passive component technology
  ISBN 0-471-24431-7
- Multi-chip modules d'hier et de demain
  ISBN 2-84054-016-9
- Electronic packaging and interconnection handbook
  ISBN 0-07-134745-3

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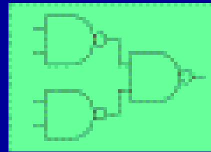

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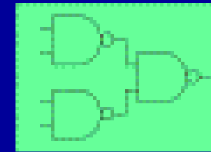

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