

1. Electroless Plating

- used for Cu plating on PWB laminates for additive fine-line processes or as the seed layer (for later electroplating) for plated through holes
- reaction must occur initially on a metallic surface (seed layer)
- palladium (Pd) and tin (Sn) are common seed layer materials
- Pd and Sn alloys are created by dipping in SnCl₂ or PdCl₂ solutions => autocatalytic reaction of metal ions from the solutions occurs
- initial copper nucleation on Pd is believed to occur because of the catalysis of the dissociation of formaldehyde
- once the surface is coated with Cu, the reduction reaction will continue (the reducing agent selected must insure that the reaction only occurs at the substrate surface and not throughout the solution)
- complexants (like carboxylic acids or organic amines) are sometimes added to control the bulk precipitation in the bath due to changes in the pH during plating; but this may reduce the deposition rate)
- exaltants or accelerators are sometimes added to combat this problem
- typical electroless copper plating bath composition

Component	Concentration (g/l)
Copper sulfate	15
Formaldehyde	10
Ethylene diamine tetraacetic acid (EDTA)	20
Sodium potassium tartrate	10
Sodium hydroxide	15

2. Electroplating

- possible for a variety of metals, including Ag, Au, Cu, Ni, and Cr
- Faraday’s law predicts the weight of deposited material as a function of the current passed through the electrode:

$$M = \frac{QA_w}{Fn} = \frac{ItA_w}{Fn}$$

where: M = mass of deposited metal (g)

Q = total charge (coul)

I = current (A)

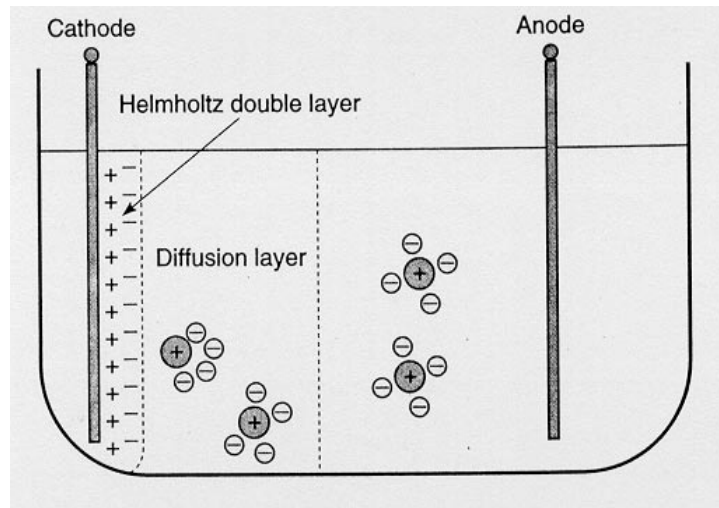
t = duration of plating (sec)

A_w = atomic weight of the metal

F = Faraday constant (9.65×10^4 coul/mole)

n = number of electrons transferred per atom in reduction reaction

- plating bath with an electrolyte inside



- before external voltage applied across the cathode, potential exists between metal cathode and ions in the electrolyte
- because of this potential, ions line up along the metal electrode as shown in the figure; this is called the *Helmholtz double layer*
- when external voltage is applied, cell potential changes from its equilibrium value by the *overpotential*, which determines the plating rate
- *diffusion region* is adjacent to Helmholtz region; ion concentration here is less than equilibrium value
- concentration gradient exists across the diffusion region due to the reduction of the metal at the cathode; forces metal to diffuse => cathode
- plating can either occur at constant voltage (potentiostatic) or constant current (galvanostatic)
- most common solution for Cu plating = $\text{CuSO}_4/\text{H}_2\text{SO}_4$ bath
- two types of copper baths:
 - 1) high speed = 50-150 g/l copper and 20-50 g/l acid; high current ($100\text{-}200 \text{ mA/cm}^2$); low conductivity => does not deposit uniformly in through holes
 - 2) high throw = 10-25 g/l copper and 150-250 g/l acid; low current ($10\text{-}50 \text{ mA/cm}^2$); better uniformity

3. Metallization: Other Considerations

- electrical performance:
 - crosstalk
 - signal reflection
 - propagation delay
 - bandwidth
 - conductivity
 - impedance and capacitance
- reliability issues
 - MTBF
 - electromigration
 - corrosion
- geometric/structural issues:
 - linewidth
 - thickness
 - flatness
 - feature size
 - packaging efficiency
- processing issues
 - cost-effectiveness
 - adhesion
 - etchability
 - resistance to subsequent processing
 - “bondability” to other interconnect
- metallization choices and trade-offs

Copper	Aluminum	Gold
high conductivity	mature technology	chemically inert
no electromigration	inexpensive	no corrosion
good step coverage	adequate conductivity	hard to etch
adhesion problems	bonding problems (due to oxide formation)	poor adhesion
corrosion problems	corrosion problems	
	electromigration problems	

- materials choices by various companies

TABLE 10.2 Materials Used by Different Companies in MCM-D Fabrication

Company	Substrate	Conductor	Dielectric
HiDEC	Silicon	Aluminum	SiO ₂ /photo PI
Alcoa	Silicon	Copper	Polyimide
AT&T	Ceramic	Copper	Photo PI
APS/Raychem	Alumina/silicon	Aluminum	Polyimide
Boeing	Silicon	Copper	Photo PI
CNET	Silicon	Copper	PPQ
DEC	Copper	Copper	Polyimide
GE	Alumina	Copper	Polyimide
Honeywell	Alumina	Copper	Polyimide
Hughes	Alumina/silicon	Aluminum/copper	Polyimide/BCB
IBM	Glass-ceramic	Copper	Polyimide
MCC	Alumina	Copper	Polyimide
MCNC	Ceramic	Copper	Polymer
Mitsubishi	Copper	Copper	Photo PI
Mosaic	Silicon	Gold	SiO ₂
nCHIP	Silicon	Aluminum	SiO ₂
NEC	Ceramic	Gold	Polyimide
NTK	Alumina	Copper/aluminum	Polyimide
NTT	Ceramic	Copper	Photo PI
Polycon	Silicon/Al/SiC	Copper/aluminum	Polyimide/BCB
Polyolithics	Temporary glass	Copper	Polyimide
Rockwell	Silicon	Aluminum	Polyimide/BCB
Tektronix	Copper	Gold	Photo PI
Unistructure	Metal	Copper	Polyimide/epoxy resin