Lecture $\boxed{2}$

HOUSING TECHNOLOGIES

Reactive transfer molder Packages

→ In micro-electronics : packaging complexity has always increased.

→ Aim is always to decrease package to chip ratio with current trends being directly allowing connection from wafer level.

Three main stages in development

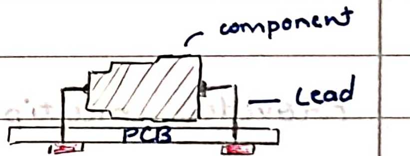
1> Through-hole technology (soldering pins within vias)

2> Surface Mounted technology (no vias directly soldered on top)

3> 3D Integration.

From through-hole to SMT Technology

A] Through-hole Soldering

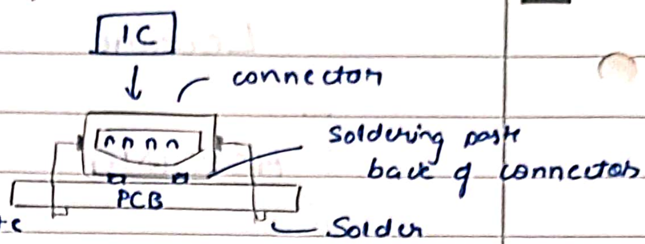


* First technique used where the component was directly soldered onto the board.
* Easy prototyping method of today
* Requires skill to solder delicate IC

Susceptible to humidity, dirt, vibration

Through hole soldering for the careful

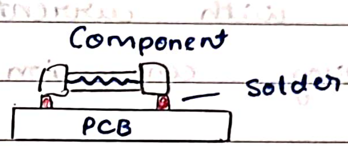
B] Connector Soldering



* If you need to solder delicate IC's choose this.
* This is also through hole but solders a heat-insensitive socket onto the board.
* We then plug IC into the socket.

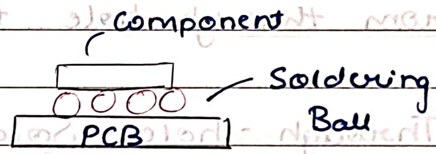
Surface mounted Technology

C] SMT Soldering



* Provides higher integration density
* If vias are not required in PCB and can work from one side (exclusively).
* SMD (Surface mounted device) soldering requires patience and practise. eg: FRAM SMD device.

D] BGA Soldering



* Provides multiple interconnects per device (to a degree where adding more pins is infeasible)
* Higher integration density
* BGA soldering requires specific instruments as the heat required needs to reach all balls in the array.

defacto since long time in board design

Through - hole technology

Advantages	Disadvantage
→ easy to prototype	→ high board cost due to vias
→ strong physical connection	→ more space required
→ relatively good heat tolerance	→ PCB assemby is time consuming

Surface Mount Technology

current state of art in board design as components are miniaturized.

→ small size, high integration density	→ weaker physical connection
→ reduced parasitic signals	→ low heat tolerance
→ cheaper boards : no drill	→ low power density
→ no vias required	
→ higher degree of automation	

Common Packaging types in through-hole & SMT

We still distinguish packages from through-hole to surface mounted. Each type has many built variants eg: DIP (Dual in line package)

Many are largely obsolete eg LCC, PLCC designs.

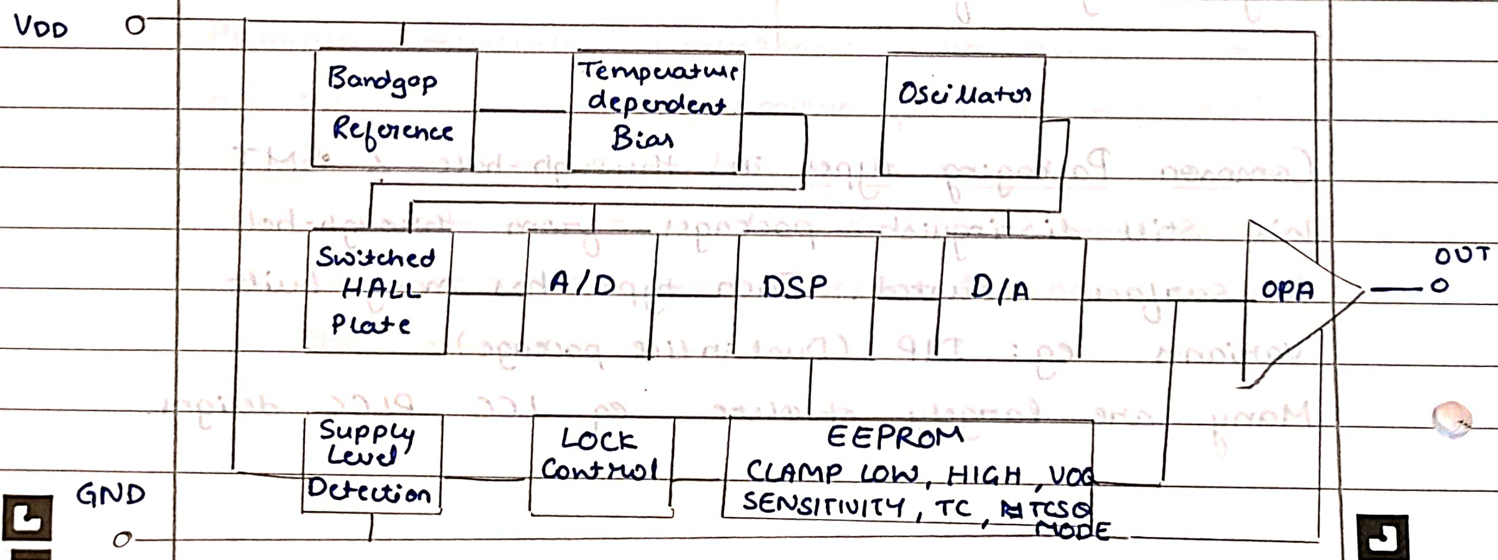
measures magnetic field

PRACTICAL EXAMPLE : HAL800 MICRONAS GmBH

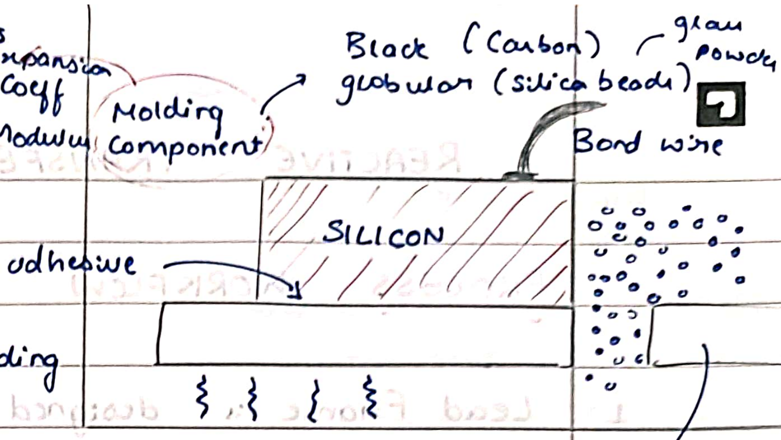
HAL800 → programmable HALL sensor with
→ various Hall sensors (monolithic integration via
→ compensation circuit single wafer processing in CMOS)
→ signal processing

* intended for automotive use at temp (-40°C - +170°C) on the junction (i.e interconnection to the device)
* molded with thermostat epoxy / SiO_2 paste
* extremely cost sensitive device
* device is adhesively bonded onto a lead-frame and interconnected with 25 μm gold wires.

→ achievable magnetic range - ±50 mT
→ offset correction from 0.2 to 1.25 mT
↳ after active offset compensation (Chopper Stabilization)
→ non linearity 0.5 to 1.5% range
→ digital interfaces, microcontroller core, EEPROM A/D & D/A converter, DSP, BUS interface.

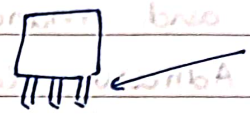


Main Props
→ Thermal expansion Coeff
→ Young's Modulus



LEAD FRAME

Main properties for the molding component are
i) Thermal expansion Coefficient
ii) Young's Modulus



The component is made of polymer + glass (Silica beads)
Glass (SiO_2) is very low thermal expansion coefficient plain Si is slightly higher. Also glass is a very stiff material [more glass → harder].

Lead Frame is a ~~semiconductor~~ ~~device~~ frame which keeps electrical components in place and leads electrical signals.

⇒ A semi-conductor device is connected to a PCB which takes care of electrical interfacing and heat management of the device. The board is not just used to connect but structurally fix the component.
The package is often over molded in order to mechanically stabilize

REACTIVE TRANSFER MOLDING

PROCESS WORKFLOW

1> Lead Frame is designed and manufactured.

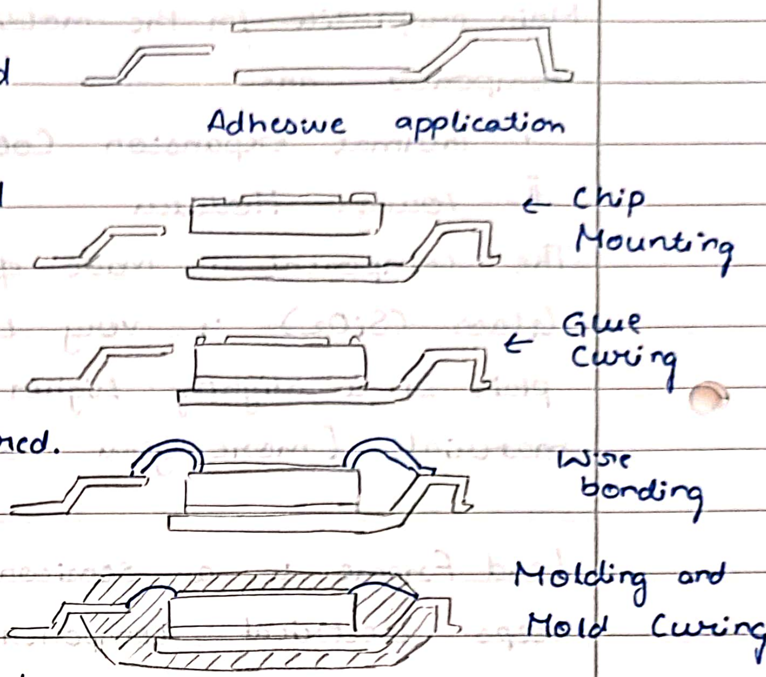
2> Adhesive layer is applied to it.

3> Chip is mounted on it.

4> Adhesive (which is thermally activated) is cured.

5> device is connected electrically via wire bonding

6> Stack is immersed in a polymer via molding and mold curing

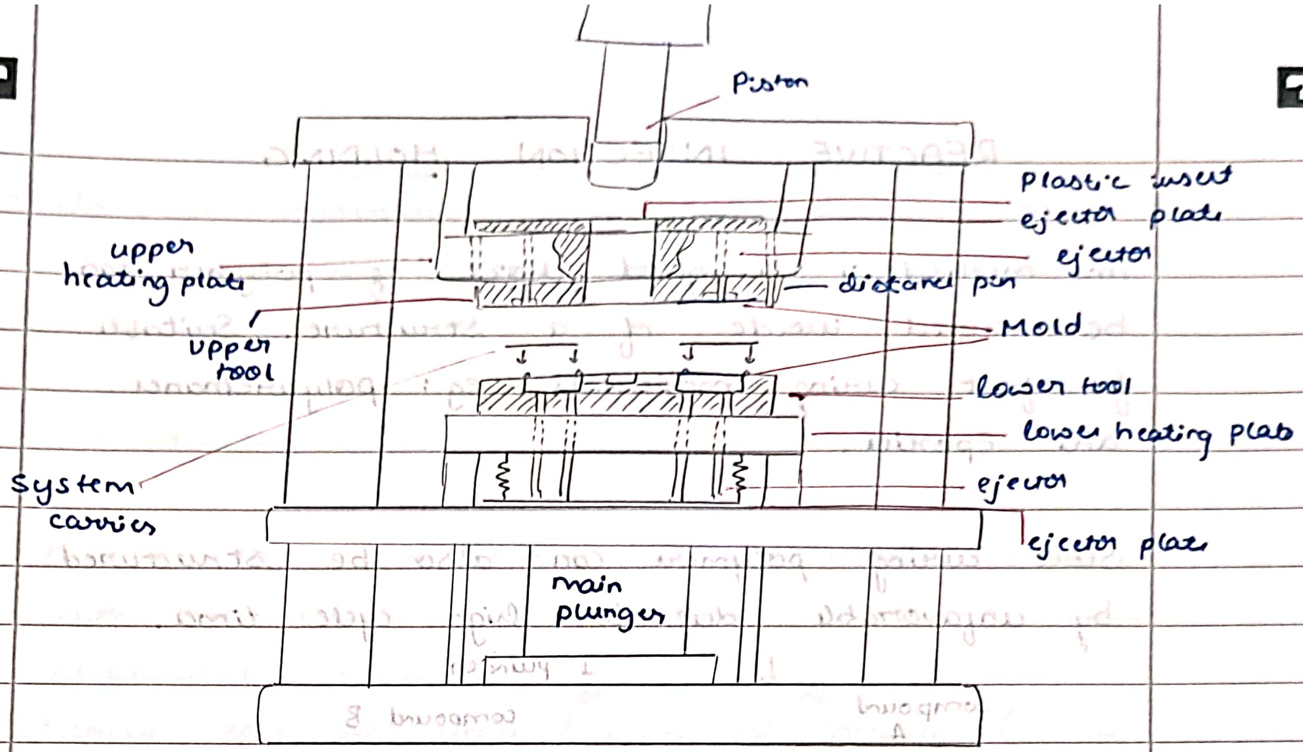


7> We get a fully embedded and physically protected and mechanically fixated device with which we can electronically interface.

8> Molding process is essentially a casting or injection molding process which allows embedding.

INSTRUMENTATION

The machines used for reactive transfer molding are fairly standard molding machines. In their variants they can be used for
- → reactive transfer molding
- → injection compression molding



In most cases, the polymer is cured in-situ which is why the process is referred to reactive transfer molding (instead of thermoplastic transfer) Reason : reactively curing systems require less heat.

STEP BY STEP

1> ICs on lead frames are loaded into the molding tool. - Pick and place robotically.

2> Molding Tool is closed which defines the cavities to be molded - then mold is pre-heated.

3> By pressure application, the material (which is a reactively curing 2-component polymer) is then pressed into the mold.

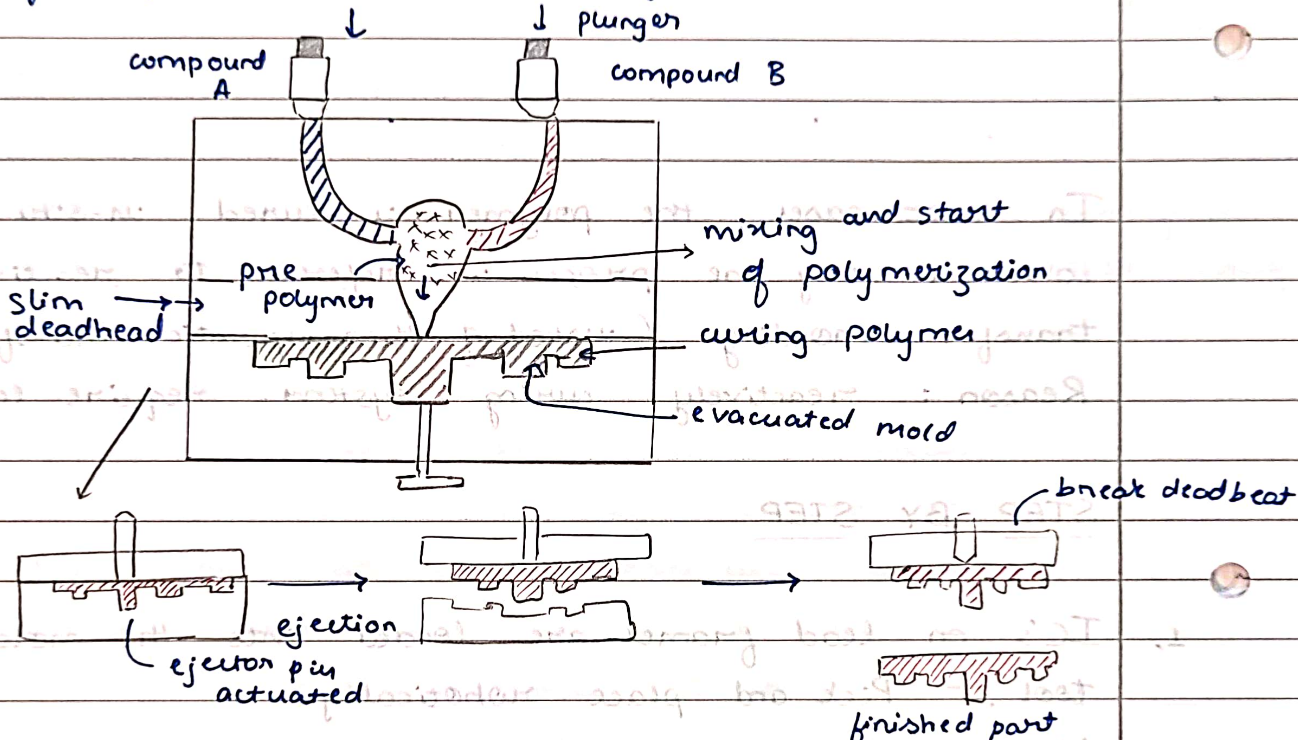
4> Mold is heated to allow the polymer to cure, then cooled and opened → components are taken out.

5> After post processing (cutting, bending leads etc) the component is ready to use.

REACTIVE INJECTION MOLDING

This method is a good choice if polymer can be cured inside of a structure. Suitable for fast curing materials eg: polyurethanes and epoxies.

Slow curing polymers can also be structured by unfavorable due to high cycle times.



RIM : Two or more components of the polymer are premixed (desirably in continous fashion) inside a mixer before being injected (under pressure) into the evacuated mold.

The finer the details of the mold to be replicated the higher the demands for perfect vaccume.

During mixing => trapped air bubbles will block in fine structures.

→ Classical materials structured by are polyurethenes (foam and solid) as well as epoxies and (less common) autocuring systems.

Advantages

→ Polymer Precursors (monomers) are mostly liquids with low viscosity which allows filling of finely structured molds.
→ Process does not require external heating (unless required for accelerating reaction)
→ Allows for designing small bench top instruments.
Low stress on molding tool during structuring
↳ usage of low quality molds (polymeric molds)

Disadvantages

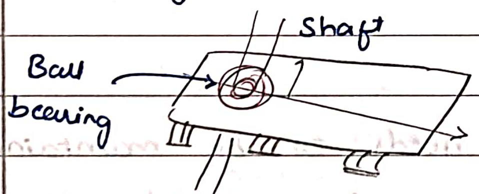
→ limited choice of materials
→ Precise process control ~~is~~ needs to be maintained otherwise polymer may polymerize inside the injector or of the mixer.
→ processing time is dependent on polymerization speed.

Eg: In industry large scale objects polyurethene mattresses, valve seat from epoxy resin, car components

Multi functional Molded Packages

- House molding gives all advantages of polymer molding → packages can have high level of functionality
- channels, connectors, valves, throttles [passive components] can be embedded with (active) IC
  ↳ this is often required eg: gas, liquid or biosensors which require medium to analyse

Example → Sensor for angular position measurement
it contains a ball bearing which guides a shaft which is connected to an external component.
=> Position of the shaft is measured with a Hall Sensor IC.
=> All components are directly molded into the housing package.



IMPORTANT MATERIALS FOR LEAD FRAME

Most commonly used (FOR lead Frame) materials are based on Iron and copper alloys.

→ Alloys are used because thermal expansion is a point of concern. (lower expansion coefficient).
→ Copper is used if heat management is an issue (due to high thermal conductivity)

Property	Iron Alloy 42	Copper CuFe2P phosph
Composition [wt%]	Fe58Ni42	Cu98Fe2 [CuFe 2.3 P0.03 Zn 0.1]
Young's Modulus E [GPA]	145	~120
Coeff of thermal expansion α [10^{-6}/K or ppm]	not very low but decent 4.3	higher is bad. 16.2
Thermal Conductivity λ [W/m-K]	15.9	262 highly conductive.

* Question : If you need thermal conductivity then copper is the choice else Iron