Semiconductor Finishing Processes

Deflashing

Under the pressure applied during the moulding cycle, small amounts of resin will often leak out between the two halves of the mould, producing ‘flash’, a self-supporting opaque film projecting around the body of the package at the point where the halves were joined, and/or ‘resin bleed’, a thin transparent film on the lead-frame. The latter is the more serious problem, since it significantly degrades lead solderability.

Thin layers are transparent because very narrow openings (<5µm) allow resin to pass but prevent the filler particles from being forced through. As the width of the gap increases, some filler is carried out and the bleed starts to look grey from 7–10µm upwards: the darker the colour, the thicker the layer. The distinction between flash and bleed is arbitrary, but typically anything thicker than 50µm would be classified as flash.

The severity of the problem will depend on:

- Mould manufacturing tolerances
- The flatness of mould surfaces
- Any mould distortion due to temperature differences
- Mould wear, which is inevitable because the materials used are abrasive
- Small variations in lead-frame dimensions
- The thickness tolerance of the lead-frame (±1% is typical)
- The clamping force exerted by the press

With fast automatic moulding equipment, designed to use smaller moulds, the problem is reduced.

Depending on the rigidity of moulding compound used and its chemical resistance, flash and resin bleed may be removed either immediately after moulding or after post cure. Four de-flashing techniques have been used: dry blasting; wet blasting; chemical; high pressure water. Both blasting techniques use an abrasive medium propelled with high velocity to mechanically remove resin bleed: some information on this is given in Figure 1.

Figure 1: Some notes on deflashing using abrasive media

Traditionally, ground walnut shells and ground apricot stones were the most popular types of abrasive de-flashing media. These are low cost, but create large amounts of dust, leave an oily residue and are not of consistent quality from year to year.

The most popular replacement synthetic medium is ground thermoset resin. This is more expensive, but lasts longer, and the plastic can be formulated in different hardnesses. The angular edges of the granules arevery effective in removing resin bleed by a chipping action.

The semiconductor industry tends to use the least abrasive and softest materials, as hard media will actually wreck the parts. For this reason alternative media (including polystyrene, polycarbonate, mineral glass beads and even brass powder), which are denser or more abrasive, are not favoured, as care has to be taken to avoid damaging components.

Mixes of materials have been tried, but combinations are difficult to maintain in consistent ratio in a production environment.

Dry de-flashing systems inject the media into an air stream which is guided to the part to be de-flashed. After striking the component, the dust created is separated from any media which is still usable, which is reclaimed. The parts to be de-flashed are moved under the nozzles by a conveyor belt.

Practical machines need a means of dust collection and of delivering the de-flashing medium to the abrasive hoses. This operation may be carried out by pressure or suction, and will probably use a dual tank design to allow one tank to be used for blasting while the other is being refilled from the media reclaim operation.

Wet blast systems use a slurry of water and abrasive materials to de-flash the parts. Since the water cushions the impact of the media, harder materials can be used, such as aluminium oxide or glass beads. This system eliminates dust and static-induced damage, and results in cleaner parts. Because there is always a cushion of water between the media, impregnation, surface damage and excessive media breakdown are eliminated.

after Singer 1985

Chemical de-flashing involves soaking parts in materials such as n-methyl-2-pyrrolidine or dimethyl furane, with additives to prevent soils being re-deposited on the devices, and surface active agents to accelerate penetration and promote rapid removal of the residue. Soaking may be carried out at elevated temperature, and with the assistance of ultrasonics. Following a water rinse, the loosened residue is removed by blasting with compressed air, high pressure water, or abrasives.

Whilst chemical de-flashing is effective, there is some concern that the materials used in may find their way into the package, degrading the device. A further problem is that some of the chemicals used are hazardous, creating problems of waste disposal.

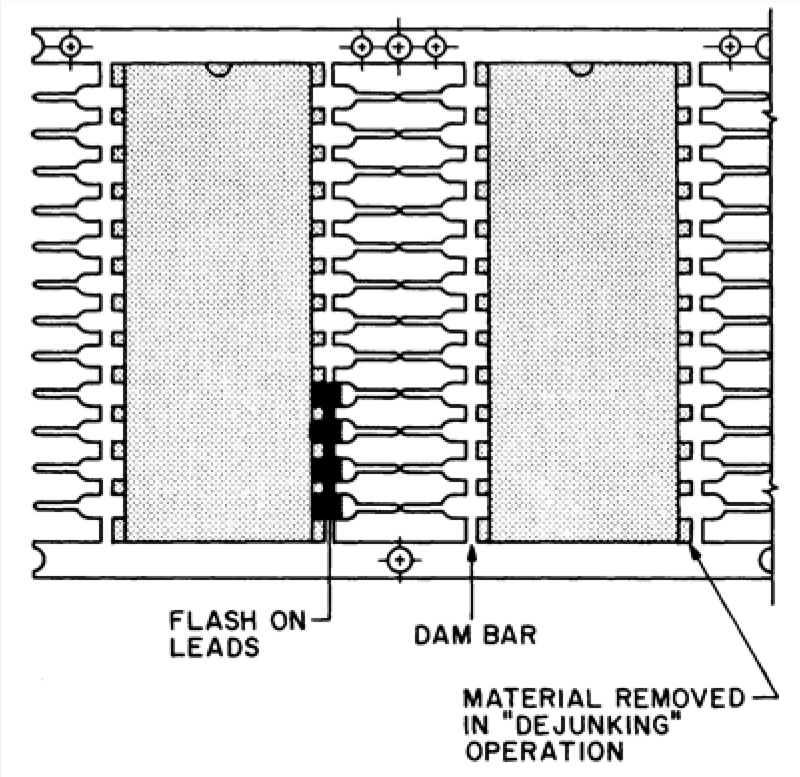
Innovations in high pressure water hydrodynamics and nozzle design have made it possible to remove flash using very high pressure water, and this is current preferred practice, *provided* always that the degree of flash and bleed can be limited by controlling the moulding process conditions and keeping the moulds well-maintained. The procedure is normally carried out *after* the flash has been made more rigid by post-cure.

Removing 'junk'

The lead-frame will usually be designed with a 'dam bar', to stop the moulding compound from flowing out between the leads. Unwanted plastic left in the area between the package and the dam is commonly referred to as 'junk' (Figure 2). Because the junk is tightly sealed between dam, body and leads, it is often difficult to remove. There are four alternative approaches:

- To use a mould with pins (sometimes called 'hibbles') to prevent the epoxy entering the dam via area. Although effective, such systems are more expensive and generally require increased maintenance.
- To 'de-junk' during de-flashing, using additional dedicated nozzles to direct abrasive material onto the appropriate areas of the package.
- To remove the junk mechanically using a dedicated die punch system as a separate operation.
- To remove junk as part of the trim and form process.

Figure 2: Drawing showing the lead-frame and package after moulding but before deflashing, dejunking and trim and form



The majority of de-junking is carried out during trim and form although, compared to separating the tasks, this increases die punch wear and breakage. Trim and form machines have therefore to be fitted with high power vacuum systems to remove plastic debris from the junk, which might otherwise find its way between anvil and lead-frame, causing the latter to be formed incorrectly.

Plating

Common lead-frame materials are copper alloys (usually with a small percentage of iron) and ‘Alloy 42’, which is an alloy of iron (58% and nickel (42%). These materials have a close TCE match with silicon and good strength and workability. Bondability is generally enhanced by spot plating with silver.

Lead-frames are generally not plated overall before assembly, and a solder surface would in any case not be compatible with the high temperatures involved in encapsulation by transfer moulding. This means that the package exterior must be solder-coated, either by hot dipping or plating.

Hot dipping is effective, but difficult to control, with fine pitch surface mount parts being liable to solder bridging and variations in coating thickness which lead to problems of package non-coplanarity.

As the parts are connected together and shorted out by the lead-frame, electrolytic plating is an option, a typical finish being 10µm of tin-lead. Depending on the application, either eutectic or 70/30 material can be specified, and the finish may be infra-red reflowed. The predominant finish is as-plated, having a dull grey appearance. Brighter finishes can be achieved by using plating additives, but, as with all plating operations, these may adversely affect solderability and ageing characteristics.

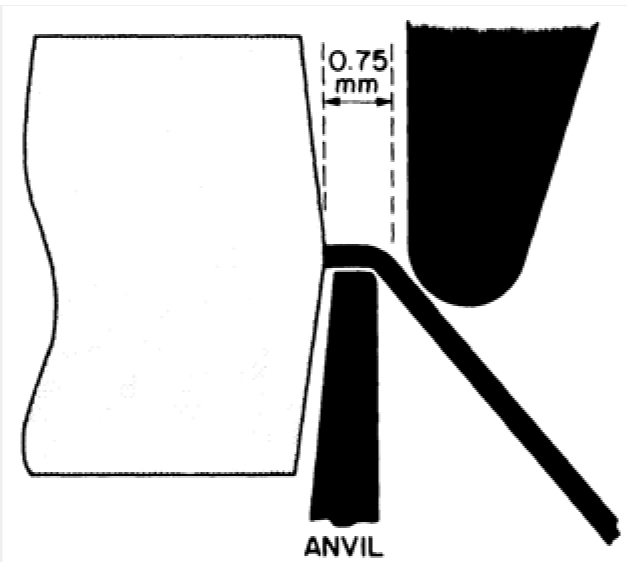
Post-encapsulation plating is effective, but there is always the danger that plating chemical residues will impair the long-term reliability of the component. One alternative, which has been evaluated with some success, is to pre-plate the lead-frame with palladium on top of a nickel under-layer. Palladium increases adhesion to the encapsulant, and is dispersed during soldering to leave a bond between the solder and the underlying nickel. Unfortunately, the surface finish is poor, which discourages users.

Lead forming

Cut and form is carried out in a reciprocating punch press, operating at around 80 strokes/minute. Progressive dies are used, with each station carrying out a single forming step, so that one multi-die press tool can carry out a complete forming sequence on each stroke. Tooling is normally made in hardened tool steel or carbide steel.

Care must always be taken to ensure that the leads are not unduly stressed and that the lead is not bent against the body, since this would crack the plastic underneath. It is normal to support the lead with an 'anvil' at least 0.6mm wide, as shown in Figure 3 for a simple lead bend.

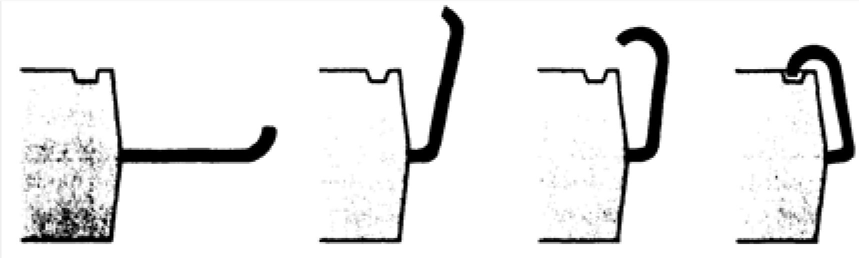
Figure 3: Tool and lead configuration for a simple lead bend



This is typical of a through-hole package form, but is also a step in making both gull-wing and J-lead packages

Tight bends may need to be carried out in two stages, in order to reduce deformation at each stage, and the more complex lead forms of typical SM devices use a number of stages: a three- or four-stage progressive die set in the case of the J-lead package shown in Figure 4.

Figure 4: Schematic of the steps in forming a J-lead package



Holes in the lead-frame strips are used to index the packages through the press, but the cycle involves the parts being 'singulated' as a final press operation, leaving the machine as separate packages, and being loaded either into tubes or trays, or directly into burn-in test jigs.

Coding

Coding adds printed information to the top surface of the plastic package. This will include the device code and manufacturer's logo: how much more data is displayed will depend on the area of the package and the definition of the coding process.

There are two primary means of recording this information: by using a marking ink on top of the surface, or by selectively abrading the top surface layer by particle blasting or (more usually nowadays) by laser machining.

Ink marking can be carried out by:

- **stamping** , with a rubber stamp that is dipped in ink and then stamped onto the moulded body
- **screen printing**
- **transfer printing** , where inked type and the body are alternately pressed against a hard rubber transfer pad
- **pad printing** , where a deformable silicone 'tampon' is used to transfer ink from an etched plate
- **ink jet printing**

A variety of inks may be used, depending on the body material and the process chosen. The most common are epoxy or phenolic based and require curing by heat or UV radiation. This process can be combined with the post-cure of the encapsulant.

A frequent problem associated with ink marking is the smearing or removal of the ink on subsequent handling, even when the ink is nominally ‘cured’. This can sometimes be alleviated by the choice of ink, or by improving the drying and curing process. More often, the problem is related to contamination of the upper surface of the moulded part or to its texture. Results may be improved by a matt or textured finish.

In **laser marking**, the information is ‘burnt in’, usually with a C0 2 or YAG laser which scans the surface to be abraded. This has the advantages that the coding is carried out immediately without any post-cure, and is indelible and that the process is very flexible, with the possibility of adding computer-generated unique identity markings.

The major problem associated with laser marking is the relatively poor contrast between the exposed area and the background, the coding having only a slightly lighter and less reflective appearance than the body of the part. Although special moulding compounds have been developed to enhance the contrast, these do not give the same readability that can be achieved easily with white ink!

Most marking operations are at least semi-automated in that the packages move on a conveyor that delivers them under the marking head. Where ink marking is chosen, then frequently coding will be carried out in two passes, the first applying generic information, and the second pass on another machine adding batch or unit detail. This approach increases flexibility and can reduce the set-up time.

Source : http://www.ami.ac.uk/courses/topics/0270_sfp/index.html