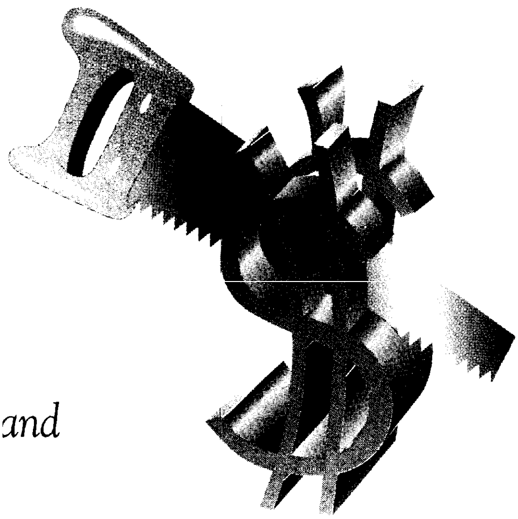
Derailing the Cost Drivers



Some simple steps for keeping expenses in check and quality on track.

David E. *Stone*

Editor's Note: As with peace on earth, goodwill toward men, and other laudable visions that rise to the fore during the holiday season, it's often a lot easier to dream the dream than to make it reality. While no one would argue the desirability of such goals, the room can get a little quieter when it comes to determining the optimum way to accomplish them.

It seemed that the best "gift" for the board fabricator this year would be economy — making the most of what you have now and finding ways to get more of it in the year to come. In the following series of articles, we present PC *FAB's* collection of cost-cutting measures to help you realize a profitable and prosperous 1995.

Reducing operating costs and improving yields are crucial to ensuring an economical printed circuit board manufacturing process. Today, every process step and its associated chemistry must be evaluated not only on the basis of process capability, but also on its compatibility with subsequent steps. As the board proceeds through the manufacturing cycle and module life, the costs associated with product fallout rise significantly (Figure 1). Therefore, defect-free results become imperative throughout the entire sequence.

The Basic Requirements

Solder mask must meet a number of requirements. It must not interfere with the assembly process, and it must retain all requisite physical, chemical, mechanical, and environment-related properties through final assembly and throughout module life.

Liquid photoimageable material is the predominant mask for today's surface-mount designs. But the increasingly stringent conformance and resolution demands of new designs, coupled with the impact of chemical and physical interactions of assembly products and processes on the liquid photoimageable solder mask (LPISM), have presented new challenges for the material and the process. Defects such as insufficient coverage/trace encapsulation, inability to produce fine LPISM features between surface-mount pads (solder dams), solder mask residue on pads, and incompatibility with the assembly process can result in costly rework or even scrap at assembly.

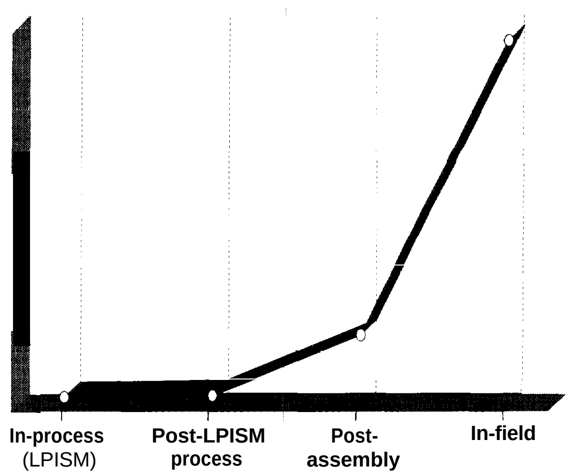


Figure f. *Cost of product fallout.*

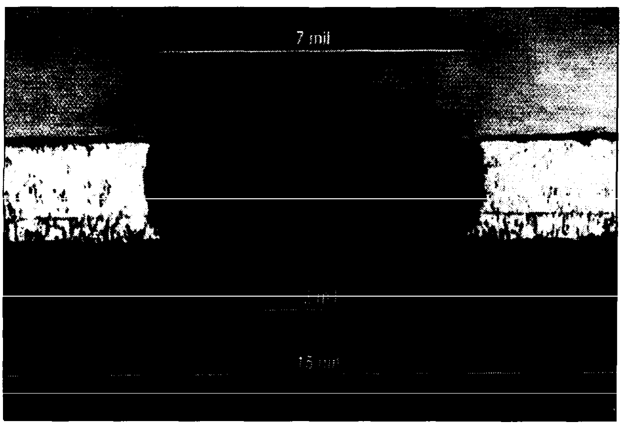
LPISM Application Methods

One of the biggest opportunities to improve product quality and reduce operating costs lies in LPISM application. The technique used must meet the fabricator's individual requirements in terms of floor space, budgetary constraints, throughput, transfer efficiency, desired degree of automation, cycle time, and volatile organic compound (VOC) content.

The three primary methods of LPISM application are flood screen, curtain, and spray coating. In open flood-screen coating, the high transfer efficiency of the screening process helps limit material waste to below 1%, and solder masks formulated for screen coating typically carry low solvent loads. Cycle time can also be significantly reduced by using double-sided screen-coating equipment. This technique, however, can require a large inventory of screens to accommodate different panel sizes. It also may deposit solder mask into through holes, which must then be completely removed during developing. Optimizing the developing process and using LPISM formulations that exhibit the most favorable developing characteristics can help ensure residue-free through holes.

Curtain coating is highly transfer efficient and involves little or no operator interaction. Incidental hole plugging is virtually eliminated. One drawback, however, is that the technique is limited to single-sided processing, requiring tack drying prior to coating of the second side. These mask formulations also contain higher solvent loads than their screenable counterparts. Finally, a panel preheat step prior to coating is recommended to ensure complete fill and trace encapsulation at circuit track spacings below 5 roils.

Spray coating generally ensures complete fill and trace encapsulation due to the uniformly sized atomized droplets this method produces. Double-sided processing is also achievable with this technique. Spray coating offers the lowest level of transfer efficiency, as the spray pattern must extend beyond the edge of the panel to ensure deposition of an even solder mask film. This typically results in 10 to 30% solder mask waste. Additionally, spray coating solder mask formulations contain higher solvent loads, resulting in greater VOC emissions.



Optimizing the tack dry, exposure, developing, and final cure steps is equally important in ensuring the cost effectiveness and quality of the LPISM application process.

Solder Dams

A major concern for today's board assembler is the tendency toward solder bridging on fine-pitch pads. One way to minimize this problem is to place small blocks of solder mask between each component site. The solder dams, or webs, prevent solder from flowing between the pads. Shrinking pitch, however, leaves less space in which to place these dams. A typical contemporary fine-pitch design requires dams as small as 0.003" wide, with future requirements targeted at 0.001". Sidewall definition of the solder dam must also be considered. As can be seen in Figure 2, straight sidewalls result in the maximum solder mask/substrate contact and provide the optimum solder dam adhesion through subsequent fabrication and assembly processing. This additional cost driver must be taken into consideration when attempting to construct the most economical configuration possible.

Post-Assembly Cleaning

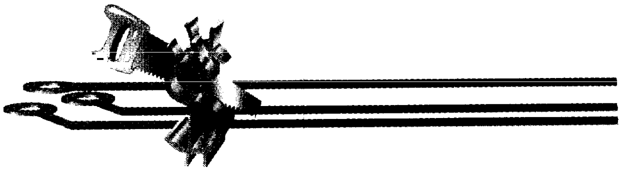
Another cost driver that must be considered is additional expense passed on to the customer. Boards that are scrapped during assembly as a result of inferior fabrication materials or processing may be returned to the fabricator at their much higher, fully stuffed price. Compatibility of the bare board with assembly materials and processes is therefore crucial to minimizing assembly defects and reducing overall manufacturing costs for both the fabricator and his/her customer.

Assembly: The Next Generation

The move from CFCs has resulted in the adoption of new assembly techniques that present new challenges for LPISMs.

Aqueous-Cleanable Fluxes

Aqueous-cleanable organic acid (OA) fluxes often produce white stains, which usually can't be removed from the solder mask surface. There are a number of potential causes of this problem, but optimization of post-wave solder cleaning parameters greatly reduces its frequency. An ultraviolet bump cure (usually at 2 to 3 J/cm^2) conducted by the fabricator following final thermal cure can reduce the severity of this problem in some cases.



No-Clean Fluxes

One consequence of using low-solids, no-clean flux is the formation of solder balls, which can cause shorts between fine-pitch surface-mount pads. Though a number of factors impact solder ball formation, undercure of solder mask film and LPISM surface hardness are common contributors. The primary culprit, however, is LPISM topography. Glossy finishes tend to produce the most solder balls, while roughened or matte surfaces produce the least. A matte finish provides less surface area to which solder balls can adhere.

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To date, no combination of mask type, flux, and wave solder assembly operating parameters has been shown to completely eliminate solder balls on the LPISM surface. As a result, many assembly facilities that use no-clean technology have established acceptance/rejection criteria based on the size and quantity of solder balls.

Conclusion

Board fabricators and assemblers face a daily variety of manufacturing challenges when it comes to solder mask. Choosing an application method, providing reliable solder dams, and ensuring compatibility with assembly materials and processes are crucial to meeting these challenges. Selecting the appropriate solder mask is a big step toward meeting the cost reduction and quality improvement goals of today's circuit board industry.

Bibliography

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