Evaluation of Bare-Board Finishes

A study of solderability.

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With the advent of SMT, product solderability has become an issue of increasing importance to the bare-board fabricator. Evaluating the solderability of some of the many available surface finishes aids in both the fabrication and assembly of PCBs.

When modern assembly techniques were being developed, solderability evaluations tended to concentrate only on the finished product. Today, far more attention is given to gathering data pertaining to solderability at each stage of the assembly process. Process inspection techniques allow quick identification of manufacturing problems. This, and the ability to relate solderability failures to particular designs, aids in identifying faults in relation to individual assembly processes. The SMART Group's (Surface Mount and Related Technologies) European surface-mount association has produced a program to make data gathering easier and more accurate. The program was used to evaluate achievable assembly yields with different protective coatings and solderable finishes and to compare the available finish technologies.

Improved data allows more attention to be directed to the PCB specification. Limiting the number of suppliers for each board design also improves the assembly operation. Previous work has shown how assembly performance can be affected by solder resists and their thickness, degree of cure, and surface finish. Attention can now be focused on the solderable and protective coatings used on SMT pads.

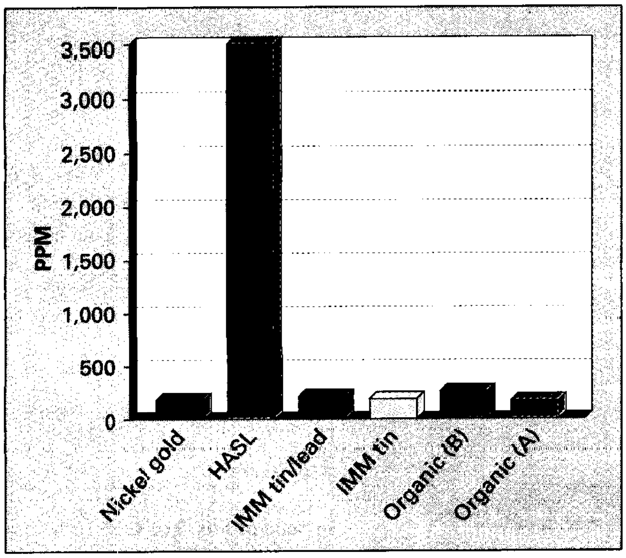

Figure 1. Total soldering defects traced to screen printing.

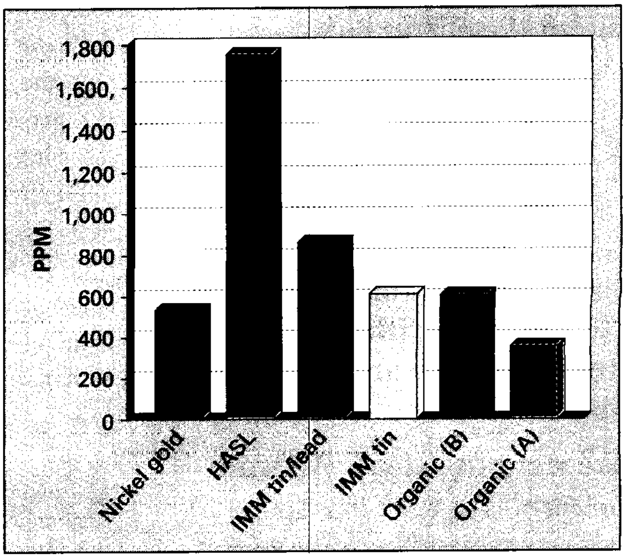

Figure 2. Total soldering defects traced to component placement

The Solderability Evaluation Program

The test boards used in the program were FR-4 fiberglass with a 1-oz. copper finish prior to the coating applications. The solder resist was a photoimageable mask compatible with the finishes. All boards were processed within two weeks of their manufacture, and all solderability testing and artificial aging was conducted within three weeks of board manufacture.

Designs for the test boards were rnade available from major pick-and-place manufacturers. The boards were designed for automated assembly and populated with chips and other fine-pitch (0.025” to 0.050”) components. Assembly operations were conducted at Dynapert (Colchester, U.K.). Marconi Communications (Chelmsford, U. K.) inspected the boards. Test conditions for the assembly processes of adhesive cure, solder paste reflow, and wave soldering were based on the test board requirement and the proposed European specification for SMT processes for component quality. Visual inspections were based on the draft European standards aligned with existing MIL/IPC standards.

The test boards were manufactured with five different finishes. Although all of the finishes were designed to promote solderability, some were developed long before surface-mount technology existed. These finishes, as well as those developed after the advent of SMT, exhibit shortcomings as well as advantages.

Flux lacquer is widely used as an inexpensive protective copper coating in the high-volume TV/VCR market. Generally confined to single-sided boards, flux lacquers are applied by dip, spray, or roller coating. Unfortunately, all the application methods yield inconsistent thicknesses, and the coatings are also porous. Due to these shortcomings, flux lacquers have a limited life expectancy. Also, some of the lacqucr fluxes are incompatible with low-residue/no-clean fluxes.

A further problem has been seen when using flux lacquers on boards requiring flow soldering. In cases where the lacquer coating is thick, the bond between the adhesive and the component is actually with the flux lacquer, not the board. During fluxing and soldering, the bond strength can therefore drop, causing components to be lost in the solder bath.

The most common protective organic coatings are the organic nitrogen compounds, benzotriazole and imidazole. These materials provide extremely thin, essentially invisible coatings that chemically bond to the copper to prevent a reaction with oxygen. The coatings are applied by dip or spray, followed by a water rinse. If coated surfaces in time become unsolderable, the coatings may be reapplied after acid etching and rinsing.

As with flux lacquers, a limitation of the azole coatings is their inability to withstand multiple soldering operations. The azoles also become unsolderable with mildly activated soldering fluxes and are susceptible to damage from humidity and careless handling.

At least three mechanically formed solder finishes are still in the developmental stage. These are SIPAD, emerging from Siemens (Germany); Optipad, developed by Velie Circuits (Costa Mesa, CA); and PPT (Precision Pad Technology), currently being patented by Christopher Associates (Santa Ana, CA). While differing significantly, each process uses solder mask as a mold to form a flat solder finish of controlled thickness on SMT pads.

The following finishes were included in the evaluation:

- solder-leveled tin/lead
- flux lacquer

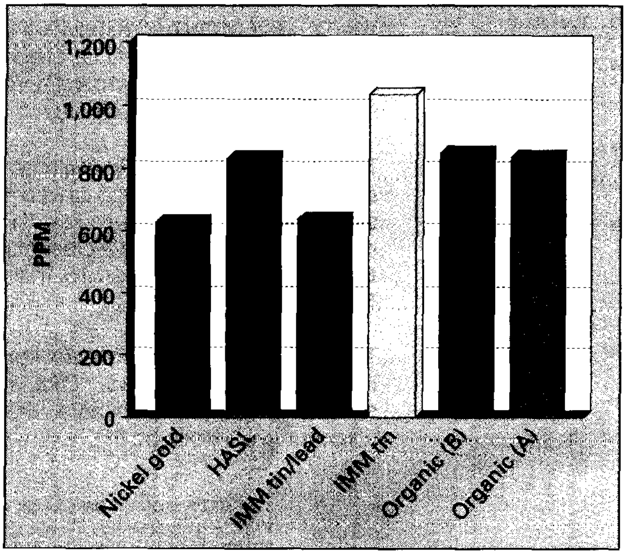

Figure 3. Total soldering defects traced to reflow soldering.

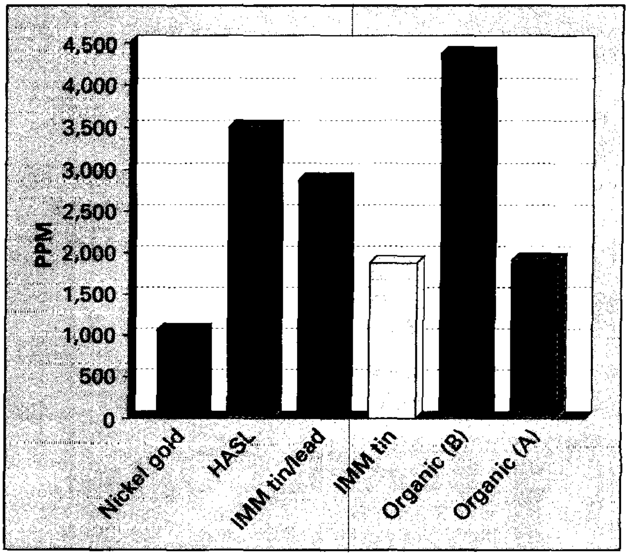

Figure 4. Total soldering defects traced to wave soldering,

- immersion tin
- nickel/gold plating
- organic coating.

Soldering and Assembly Yields

The reflow soldered test boards were populated with 430 components with 1,720 terminations. Wave-soldered boards were assembled with fewer components and held no PLCCs or QFPs.

Shown in total defects, Figures 1 through 4 illustrate yields from test boards manufactured with four of the five different surface finishes at progressive points in the assembly process. Solderability variations were measured with a Multicore micro-wetting balance.

Conclusion

The following conclusions can be drawn from the exercise:

- The solderable finish specified for SMT hoards can have an effect on the screen printing of solder mask, the placement of SMT components, and the subsequent solder joint quality and yield.
- Solder paste printing quality was satisfactory for all finishes except for the solder-levelled board, where evidence of solder scoop and skips resulted from the dome of the pad entering the stencil opening.
- Minor placement problems were mainly attributable to the uneven finish on pad surfaces.
- Variations in solderability were generally seen on all surfaces due to artificial aging and the number of soldering operations. Dry aging—as opposed to steam aging—has long been considered the most effective of these processes. However, attributing the correct time and temperature to dry aging in order to simulate a year's real-time storage remains a problem for the PCB industry. FAB

Biography

"solderability Testing Made Simple." ,'*SMART* Group videotape.

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