Understencil Wipe Cleaning Yields Improvements

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Understencil wiping has gained growing interest over the last several years. Due to the use of ever smaller components and increasingly dense interconnections in the design of printed-circuit boards (PCBs), stencil cleanliness is more important than ever, both inside the aperture wall and on the seating surface of the stencil. In most stencil printing processes, dry wiping the stencil's bottom side has been followed by vacuum assist in an effort to remove excess solder paste from the aperture walls. As stencil apertures shrink in size, more frequent wiping is needed to assure that stencils are free of excess solder paste that can hamper their process performance.

Two technology approaches are being applied with greater frequency to improve print performance and better understand the behavior of flux-stencil interactions. The first of these is a nanoscale flux-repellent coating (for more details, see "Surface Modulation Technology," Aculon, www.aculon.com). The coating is used to treat the metal stencil surface to prevent solder paste from sticking to it.

The second technology wets the understencil wipe with a solvent-based cleaning agent. The cleaning agent dissolves the flux component of the solder paste to improve the release of solder balls from the stencil's bottom side and aperture walls.

As the PCB and stencil separate, the flux releases more easily from a nanocoated stencil than from an untreated stencil.

The repellent treatment prevents the flux from wicking out around the aperture edges. Preventing flux from wicking on the stencil's bottom side also prevents solder paste particles from wicking onto it too, thereby improving the gasketing between the stencil and the PCB.

Earlier this year, Shea Engineering Services and Vicor studied the effects of Aculon NanoClear nanocoating on flux flow. The use of nanocoating was found to reduce the flux buildup on the bottom side of a stencil. In this case, the flux was tightly aligned with the apertures. When no wipe was used on a stencil without nanocoating, the flux spread away from the apertures. The nanocoating provides repellency action, keeping the bottom side of the stencil cleaner after repeated prints without underwiping. When a dry wipe is performed after 10 prints, the repellency action is even more obvious. When a dry/vacuum/dry cycle has been applied to the bottom side of a nanocoated stencil, the wipe removes excess flux, but leaves some smears behind. On the stencil without nanocoating, a heavier residual buildup occurs around the apertures with a thicker film of flux spread across the entire bottom surface of the stencil.

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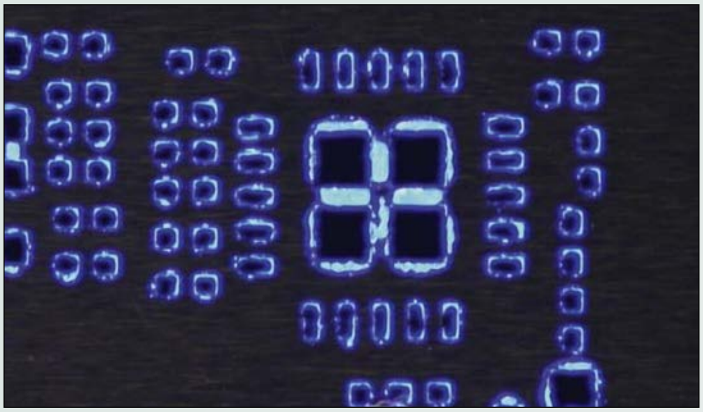
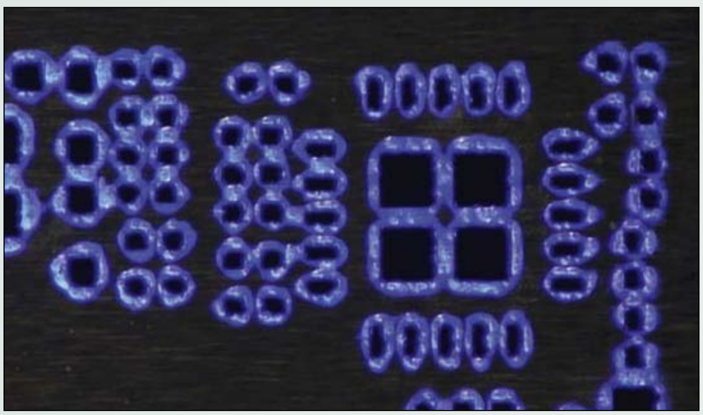


Nanocoating helped to reduce the flux buildup on the bottom side of a stencil.



For a stencil without nanocoating, the flux spread away from the apertures.

Automatic Wiping

Automatic solvent wiping was not an option during this test, so hand wipes with solvents were followed by a dry/vacuum/dry wipe cycle on the printer. The nanocoating enabled much better cleaning with the mimicked solvent wipe.

For those considering the best approach to an understencil wipe, many factors impact wipe frequency requirements. In general, miniature, high-density designs require more frequent wipes because they present more opportunity for errant paste to remain in the stencil's apertures or to stick to the stencil's bottom surface after separation. Wipe frequencies can range from every print on a highly miniaturized product to every 10 to 20 prints on a low-density design. Wipe frequencies also depend on many wipe process variables: dry, solvent-based, vacuum, wiper-type, paper/fabric-type, and advance rate, wiper speed, and wipe sequence.

Joint Study Performed

Earlier this year, Kyzen and Indium Corporation also performed a study to characterize the relationship between wipe processes and bottom side stencil flux/paste flow. A highly dense PCB and a stencil with nanocoating were used to study the effects of the understencil wiping process. After each print, the stencil was removed from the stencil printer. The apertures were examined to inspect build-up in both the apertures and bottom side of the stencil. Some trace solder balls were found following the first print, with a build-up on the bottom side of the stencil after additional prints. As expected, solder flux combined with solder balls increased with additional prints. A risk is that flux and stray solder balls can be deposited next to the stencil aperture on subsequent prints and get transferred to the PCB. Also, small apertures become clogged at a faster rate.

In the dry wipe studies, there appeared to be streaking on the bottom side of the stencil. On closer examination, the flux vehicle tended to become wiped over the bottom side of the stencil. This effect correlates with what Shea Engineering and Vicor saw from their research. Increasing the numbers of prints increased the level of flux spread on the bottom side of the stencil.

As the board being printed is sandwiched to the stencil, there is a risk that the errant flux can be deposited onto the surface of the board. There may or may not be a reliability risk.

Isopropyl alcohol (IPA) is the common solvent choice when a wet wipe is used. Historically, the choice of IPA made sense as most solder flux formulations were based on IPA. However, solder paste manufacturers are moving away from IPA-based fluxes for several reasons, the most notable of which is higher soldering temperature alloys. IPA is a flammable solvent with a flash point (the minimum temperature required for a substance to produce flammable vapors) of +12°C (54°F), which can be a risk factor.

Flammability Considerations

In addition to the flammability considerations, IPA is also becoming an inefficient solvent for modern solder pastes. When natural rosins were the primary constituents of solder paste flux, IPA was an excellent choice of solvent. Because rosin is highly soluble in IPA, the IPA readily evaporated, and the IPA was extremely affordable. Current fluxes, however, especially no-clean formulations, contain materials not as soluble in IPA as rosin, and require more specialized solvents. The solder paste used for the Kyzen-Indium research was a lead-free, no-clean formulation. Following the IPA/dry wipe action, the bottom side of the stencil was dry and mostly clean. Similar to the dry wipe, there appeared to be flux streaks on the bottom side of the stencil. There also appeared to be flux streaks on the bottom side of the stencil in the third sequence of the IPA/dry/vacuum sequence.

As part of the studies, a solvent-based stencil cleaning agent effective at cleaning no-clean, rosin-based, wet solder pastes was evaluated. The engineered cleaning agent works upon the flux resin components within the wet solder pastes. The engineered solvent composition cleans and removes solder paste that tends to adhere to the aperture walls and bottom of the stencil. Using this solvent helped maintain the bottom side of the stencil free of flux stains. Unlike IPA, this solvent is formulated within the combustible range. Due to its lower vapor pressure, it dries somewhat slower than IPA. Following the dry + vacuum wipe process, the bottom side of the stencil was dry, but for slower evaporating solvents, a second dry wipe may be a good practice.

The last solvent studied was a solvent-water azeotrope engineered composition, with uniform evaporate rate, nonflammability, and low-VOC content. The potential risk of using this type of wipe solvent is its effectiveness at removing no-clean flux resins and drying effectiveness following the wipe sequence. When used in the wipe/dry/vac process, it did not appear to clean the no-clean flux vehicle as well as the engineered solvent wipe. Of greater concern was a light film of the solvent-water azeotrope on the bottom side of the stencil after the wipe sequence.

Using an engineered cleaning agent to wipe the bottom side of the stencil presents some risk. Chemically assisted wiping can contaminate the solder paste. To mitigate this risk, understencil wipe cleaning solvent must both clean and readily dry from subsequent dry wipe and vacuum processes.

Desirable properties of an understencil cleaning agent include (1) the capability to rapidly dissolve the solder paste flux vehicle; (2) material compatibility with the nanocoating and equipment; (3) being nonflammable; (4) having low odor; and (5) having sufficient volatility to rapidly evaporate and dry post cleaning. Deficiencies in any of these properties can reduce process repeatability and reproducibility.

Two new, separate engineering studies researched the behavior of flux and solder paste flow and removal. Both visualized the flux behavior on the bottom of the stencil. One characterized the effects of nanocoating treatments; the other characterized the effects of underwipe process variables. Research by Vicor and Shea Engineering Services found that a nanocoated stencil produced better print quality than an uncoated stencil. Less flux was found to bleed out onto the bottom side of the stencil, and print definition was improved. Results from this study was presented at SMTA International in October, 2013, with the complete study to be published at APEX International in March, 2014 (for more details, see C. Shea and Whittier, "Evaluation of Stencil Foil Materials," Supplier and Coating, SMTAI, 2012).

Research by Indium and Kyzen revealed that recent understencil wipe solvents worked well with the flux compositions of lead-free solder pastes, and removed fluxes more effectively than IPA. Engineered understencil wipe solvents removed the flux stains and left a dry surface following the wipe sequence. Solvent-aqueous understencil wipe solvents appeared to clean well but were slower to dry, and may require additional dry wipe and vacuum steps to ensure complete removal. This study will be published at SMTA sponsored technical sessions during 2013 and 2014.

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