Tech Article

Stencil Wiping Fabric Improves Stencil Printer Through-Put

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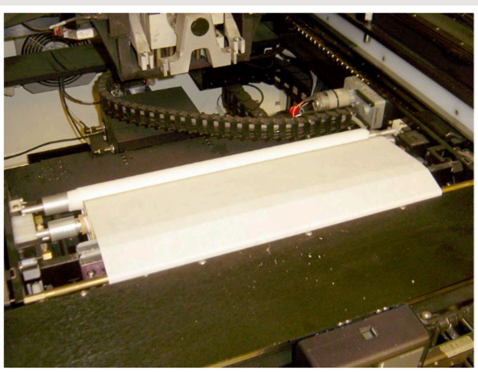
An MPM UP2000 Stencil printerat a facility in Mexico



The stencil roll positioned in an MPM UP2000 Stencil printer in the pre-wiping position

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Stencil printing has been one of the core technologies at the heart of the surface-mount revolution of the 1990s. But despite years of efforts by numerous and talented individuals, cleaning the stencil during the printing process has remained a troublesome area. MicroCare and DuPont (now Chemours) finished a comprehensive review of automatic under-stencil cleaning. The research strongly suggested that today's stencil rolls are sub optimal in fine-pitch applications. The DuPont labs assembled and tested a large number of new stencil wiping materials and tested the samples on thousands of PCBs at four major production facilities. The research has confirmed that a new stencil wiping fabric can contribute important improvements to the stencil wiping process which can significantly enhance through-put while reducing production costs.

The Electronics Revolution

Looking back over the years, it's hard to realize that today's electronic revolution was not a foregone conclusion. From your new iPhone to weather-tracking satellites and autonomous vehicles, in today's world everything uses electronics to a degree never envisioned just a few decades ago. At the heart of this change is the dramatic increase in circuit density enabled by the surface mount assembly process. The famous Moore's Law predicted smarter chips, but the chips themselves were prisoners of the board assembly process. The key to jamming more, larger, smarter and hotter components into an ever-shrinking space has been the rapid deployment and improvement in surface mounting technology (SMT).

History of SMT

When surface-mount technology first debuted in the mid-1980s, it was seen as an overly complex answer that demanded too many changes of both processes and products. But those investments and upgrades were made because the SMT process, when fine-tuned, delivered economies of scale and through-put which could be achieved by no other technology. The total annual value of the electronics assembly industry is in the hundreds of billions – a staggering output by any measure. The vast majority of this output is in the form of surface-mount circuit boards.

At the heart of the SMT process is stencil printing. Strikingly simple in concept, stencil printing is the weakest link in electronics production. The mere complexity of the process is causing costs to rise and yields to fall. It is estimated that there are typically 39 process variables that must be controlled in today's stencil printing process. In another perspective on the limits of current technology, some experts estimate that more than 50% of today's production defects are caused by errors in the screen printing process. So, the conclusion is clear: fix the stencil printing process and engineers can make dramatic improvements in their defect-free through-put.

Research by scientists at DuPont suggest that engineers looking to improve their stencil printing processes should change their stencil wiping paper.

Stencil Wiping Technology

Automatic understencil stencil wiping is one of the key processes which keeps this delicate process humming. In most stencil printers a small roll of high-purity paper installs inside the stencil printer. At programmable intervals the machine pauses while the wiping subsystem wets, wipes and dries the stencil. This process normally takes about 45 seconds and repeats every five to ten printing cycles.

It is not widely appreciated that there are two general types of stencil wiping paper: materials made with glues (or “binders” as they are known in the trade) which technically are paper, and materials made without glues which are more accurately termed fabrics. The most popular of non-glue fabrics, the DuPont Sontara® wipes, are a mix of polyester and cellulose. DuPont stencil wiping materials avoid the use of binders by relying on a proprietary “hydroentangling” process where the fibers lock together using high-pressure jets of water, heat and pressure.

Less expensive papers are available. However, they use glues or binders to hold the fibers together. These generally are either relatively thick polyester-cellulose materials or thin, hard polyester-rayon papers. As measured by weight, binders can amount to 30% of some nonwoven products.

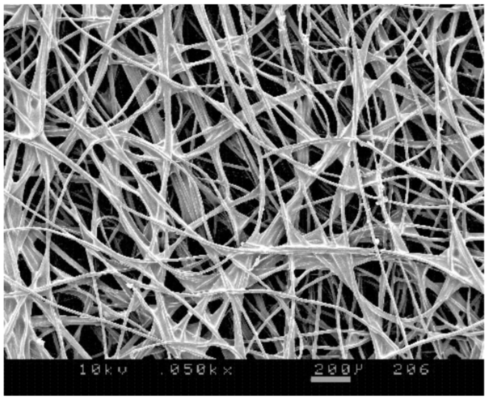
There are two problems with stencil wipes made with binders. First, despite the fact that most wipes are wetted with solvents during cleaning, papers made with binders usually have little or no wet strength. This leads to poor wiping and extensive linting on the stencil. In addition, most binders will dissolve when exposed to the solvents used in solder paste which leaves residues on stencils and boards.

The Research Program

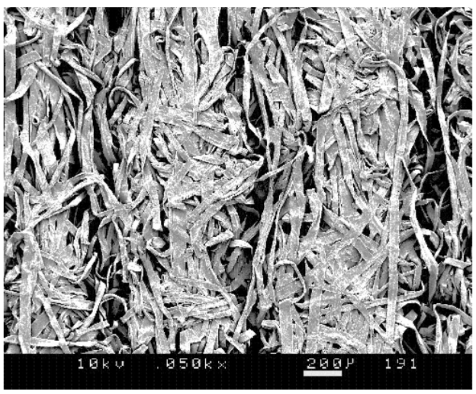
DuPont became aware that process engineers were having through-put problems with fine-pitch production. While the existing paper wipes worked well on traditional “fat pitch” SMT designs, new fine-pitch stencils were not cleaning satisfactorily. The result can be dramatic. There are 50-mil SMT lines where cleaning happens rarely, every 12-20 print cycles. On the other hand, troublesome fine-pitch designs require cleaning after every print cycle to achieve acceptable yields. DuPont suspected that a different fabric technology, if one could be found, might minimize these problems and boost SMT yields.

While this is not an unexpected suggestion for a company that makes paper, the concept that the wiping material could make a difference apparently is not always obvious to the electronics industry.

DuPont assigned Dr. Kim Abbett to the research project. At the time, Dr. Abbett had just joined the DuPont Research and Development Labs in Old Hickory, TN as a senior researcher. She began with a detailed search for new fabric opportunities. This produced a short-list of fibers that had some potential as a replacement stencil wiping paper. The typical sample was usually about five square meters of material. Pre-screening confirmed all of these candidate fabrics could be available in sufficient quantities, of sufficient quality, and at appropriate costs, to be a reasonable candidate as a stencil roll.



Microphotograph of polyester paper and the binders (glues) which lock the fibers together. Most solvents dissolve these glues, weakening the paper.



A hydroentagled paper using cellulose to absorb solder paste. Cellulose is highly absorbent but lacks tensile strength, leaving lints on stencils.

The Definition of a Good Stencil Wipe

Then Dr. Abbett discovered there was no meaningful and consistent definition of a “good” stencil wipe. So she developed a new testing protocol using an automated Gardner Abrasion testing system which allowed her to systematically compare the performance of different wipes. The process used a set of test coupons which were systematically scrubbed by a small device for a prescribed number of cycles. The result of the test was computed as a percentage of soil removed from the coupon.

The validation of the new test was time-consuming. First, Dr. Abbett calibrated the test using known fabrics. Then a series of tests were performed varying the number of scrubbing cycles. Other tests were performed on different types of solder pastes. Still another series compared cleaning with and without solvents on the papers. Once a standardized process was defined with reproducible results, all of the potential fabrics underwent testing.

From these tests, there were two conclusions. First, there was substantial variation in the ability of different fabrics to remove solder paste, and there was one fabric which out-performed all the others.

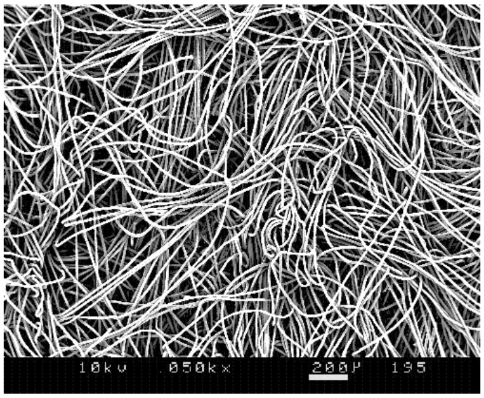
Field Trials of the Fabric

The material is a hydroentangled, single fiber nonwoven fabric. It contains no cellulose and no binders. Under a microscope, the long, thin, hard fibers appear identical and homogenous, giving the fabric an open, almost hollow structure. When assembled in to stencil cleaning rolls the material is white, softand fluffy. The fabric is highly absorptive and scores very well on the solder paste pick-up test for non-liquid contamination.

Once Dr. Abbett had found a fabric that showed promise, she prepared sample stencil rolls and asked MicroCare to assist in finding locations for field trials. Before the trials would finish, more than 1,000 stencil rolls would be consumed at seven large OEMs and subcontractors in North America and Europe. It was a grueling “real world” test for the new fabric.

The Initial Trial

One of the first trials happened at a large subcontractor with more than a dozen surface mount lines installed. They were having problems on one particular line with a large, complex and dense mother board assembly. Their current stencil roll was a polyester-rayon material containing a resin binder. The wiping process was fairly slow, in part due to the size of the boards. In normal operation, the printing process took 36 seconds per board. This established a maximum theoretical throughput of 100 boards/hour. However, the cleaning cycle consumed 108 seconds, and every third cycle the cleaning process expanded to include wiping with solvent which slowed the process even more.



Microphotograph of the FP fabric.
The hydroentangled material does not use glues or binders, nor any cellulose. This delivers better and less expensive cleaning without linting on the stencils.

Printing was further delayed because the inexpensive paper could not achieve the client's cleaning performance standard. The client's specification was to clean every five printing cycles. But at that level the line's yields fell to unacceptable levels due to misprints and fibers on the boards. When the cleaning reduced to every four printing cycles yields rose to sustainable levels but overall throughput dropped. The difference was due to the time wasted on cleaning cycles.

The Expanded Trial

The client tried the stencil fabric and began extending the number of printing cycles between each cleaning cycle while tracking yields. The fabric was able to extending printing cycles up to every 10 printing cycles without any degradation of yield. In addition, the in-line 2-D inspection system determined that the cleaner stencil allowed more paste to move through the apertures and onto pads.

Overall, the stencil wiping fabric reduced the cycle time needed to clean the stencils. This permitted the printer to boost throughput to 55 boards per hour from 32 boards per hour. Obviously, this is a significant boost in productivity on the SMT line if the stencil printer is the production bottleneck. There were additional cost savings since the stencil rolls lasted longer.

Additional Tests in Mexico and Europe

Another large scale test conducted at an OEM facility in Mexico produced impressive results. The client was wiping every five print cycles. The print cycles lasted 22 seconds with their wet-wipe cleaning cycle programmed for 43 seconds. The customer attempted to eliminate the wet-wiping cycle in an effort to speed production and reduce costs.

With the new fabric, the customer noticed significant improvements in stencil cleanliness. This enabled them to completely eliminate the wet-wiping cycle while keeping the dry cleaning cycle fixed at every five print cycles. This modest change resulted in a theoretical improvement of about 9% overall. There also was a small cost savings from the reduced usage of stencil rolls.

Other test results from Europe indicate the cost savings and through-put improvement are almost universal. At a large subcontractor with 20 high-speed SMT lines, the engineers were able to switch from wiping every four boards to wiping every ten boards. This resulted in a theoretical 17% improvement in stencil printer throughput on the test lines. In addition, because the stencil rolls last longer when used less, this customer estimate a 60% reduction in stencil roll costs (about US$32,000) with the new paper.

One big subcontractor facility has just tested the FP paper. They expect to save US$400 per week on rolls and boost throughput by 18%. These numbers represent significant cost savings and revenue enhancement opportunities for these companies.

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Conclusions

Dr. Abbett's research has been able to confirm a number of important developments. In general, she has developed a stencil wiping fabric that offers superior performance in laboratory tests and also demonstrated improved throughput in prolonged field trials. Because the wipe is completely synthetic it avoids the inconsistencies and contamination caused by soft natural fibers and binder residues. This wipe made a statistically significant improvement in through-put during numerous field trials.

About the Author:

Mike Jones, retired Vice President of International Sales for MicroCare, has over 30 years of experience in the critical cleaning industry. He is a prolific writer and educator focusing on critical cleaning in general and vapor degreasing and benchtop cleaning in particular. For more information, visit www.microcare.com.