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Article Improved Design of Dry Film Resist Laminator for Optimal Transfer of Micron-sized Features

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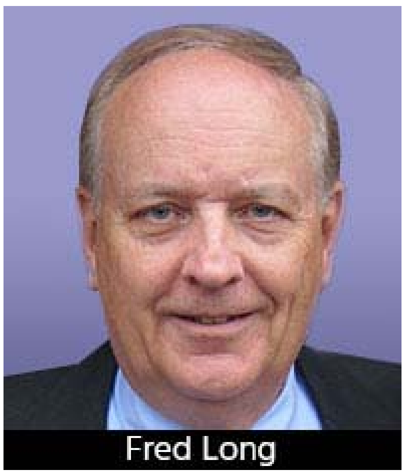


Introduction

Since the inception of dry film lamination, the process of squeezing two hot rolls at their end axis points has caused roll bending. An innovative process has now been developed whereby the film is attached with a process that minimizes this issue and provides optimal, evenly dispersed heat and pressure across the entire surface of the panel. This simple and elegant design will ensure that the integrity of the resulting image will be ideal, as measured by the continuity of the resulting transferred traces and features.

Electronic printed circuit board packaging is reaching its limit because of micron requirements, defined here as features below 5 mils (0.005”), or below 125 microns.

Over the years, front-end activities in the PCB manufacturing shop have changed from manual artwork to digitized input to vector photoplotting to phototools generated from digital/raster input. Today, digital imaging produced by either laser or projection techniques has solved the micron situation with great success.

So with our front-end issues resolved, we move to the next and key intermediate process step. This is arguably one of the most important PCB processes: the application of dry film resist to the copper surface.

Historically, here is where we continue to see faulty transfer of the original image to the copper surface. The current (and old) way of pressing down the dry film is simply inadequate. Rolls bend, resulting in low pressure in the central areas of the copper-clad panel. This can cause open circuit situations due to breaks in the copper images. These are, of course, most evident and critical on micro features (i.e., less than 0.005” [5 mil]).

The industry has made great strides in the past 20 years, but we still continue to look for ways to deal with the micron issue throughout the fabrication process. One at a time, we see these obstacles being corrected. This article highlights one of the most important steps to continue the goal of attaining optimal yield and success with the available tools.

The Innovation

Consider that we have just been handed an outstanding direct imaging database, almost perfect in every way with panel and feature dimensions meeting the most stringent micron requirements. Better yet, if environmental factors cause unexpected material movement, we can alter the data base with precise micron adjustments.

Our industry has been plodding along, not paying attention to a serious compromise since the inception of dry film lamination. From the 1950s–1980s this was not a problem, but with time, those micron requirements have been speeding our way.

While it appeared to be a perfectly adequate solution for applying dry film to copper, we have accepted the squeezing of two hot rolls at their axis ends to be our process standard (Figure 1).

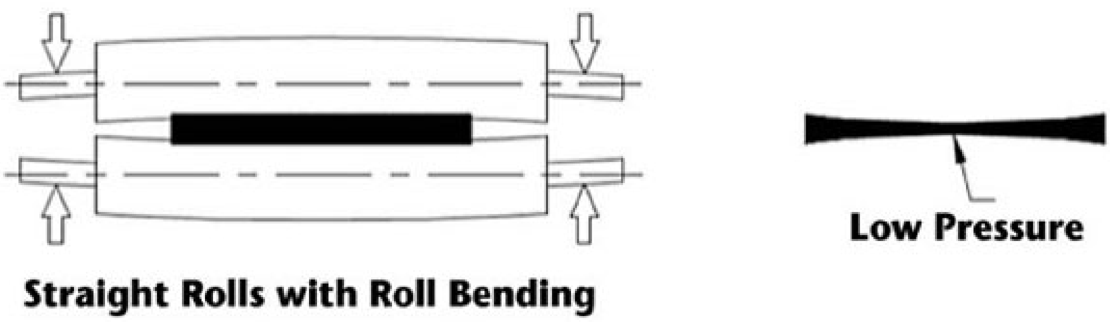
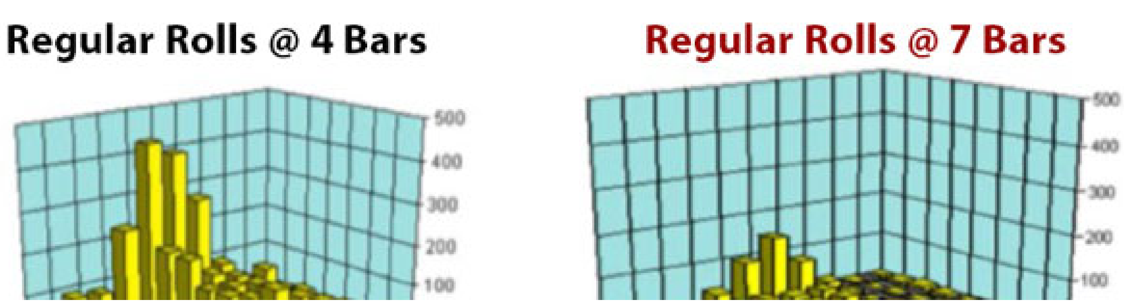


Figure 1: Roll bends.



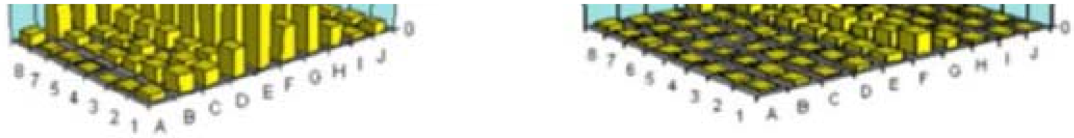


Figure 2: Pressure comparisons.

Note: Figures 1 and 2 are historical data seen for several years in various publications. The information has always been acknowledged but never rectified—until now.

Figure 1 is an exaggerated graphic that shows how the rolls will bend no matter how much pressure is applied at the ends. It is pure physics, and in fact, the more pressure applied, the worse the bending. If one were to measure the pressure along the length of the roll, we would see high pressure being applied to the ends and the pressure would become less as we move toward the center. The higher pressure at the ends, combined with certain types of softer dry films, will most likely provide proper film adhesion with acceptable film conformance. However, moving toward the center of the rolls, and with certain types of films, there can be literally no pressure (Figure 2).

Again, this worked well when features were in the 10 mil (0.010”) range, but as features began to reach our micron status, dry film adherence to the copper was random and without conformity. More importantly, if the copper surface has small imperfections (pits and dents), dry film needs to be pressured into those areas with firm and predictable results, otherwise the resulting image on the dry film will not transfer properly, and in most inner layer cases, will cause open circuits.

Further, as equipment reaches the end of its useful life, machine tolerances begin to play havoc with our most important requirement —transferring micron features.

Over the years, engineers wrestled with the problem and attempted several corrections:

1. Heavy duty rolls were made with stiff and stronger shafts to minimize the bend.

2. Rolls were tapered to provide a slightly larger diameter in the center and graduating smaller to the ends.

3. A cantilever mechanism was patented in an attempt to counteract the roll bending. The problem was better, but not fully corrected.

These attempted solutions failed to eliminate the shortcoming.

Figure 3: The elegant solution.

Consider a stainless steel, heavy barrel drum applying pressure onto a standard-type rubber roller. Internal infra-red heat, controlled and evenly distributed inside the steel drum, transfers directly to the rubber roller providing optimum distribution of heat and pressure—almost no traditional hot roll bending. Further, if it is detected that there is some bending, which would have minimal effect on the smallest micron features, there would be an option to taper the steel drum to the point of optimizing the even-pressure requirement.

Another feature and machine by-product of this solution demonstrates how a standard rubber roller could be simply replaced due to damage or if a different durometer rubber is required for certain applications. This is just what the doctor ordered for applications like flex circuits and high-profile features requiring special film conformance to the copper.

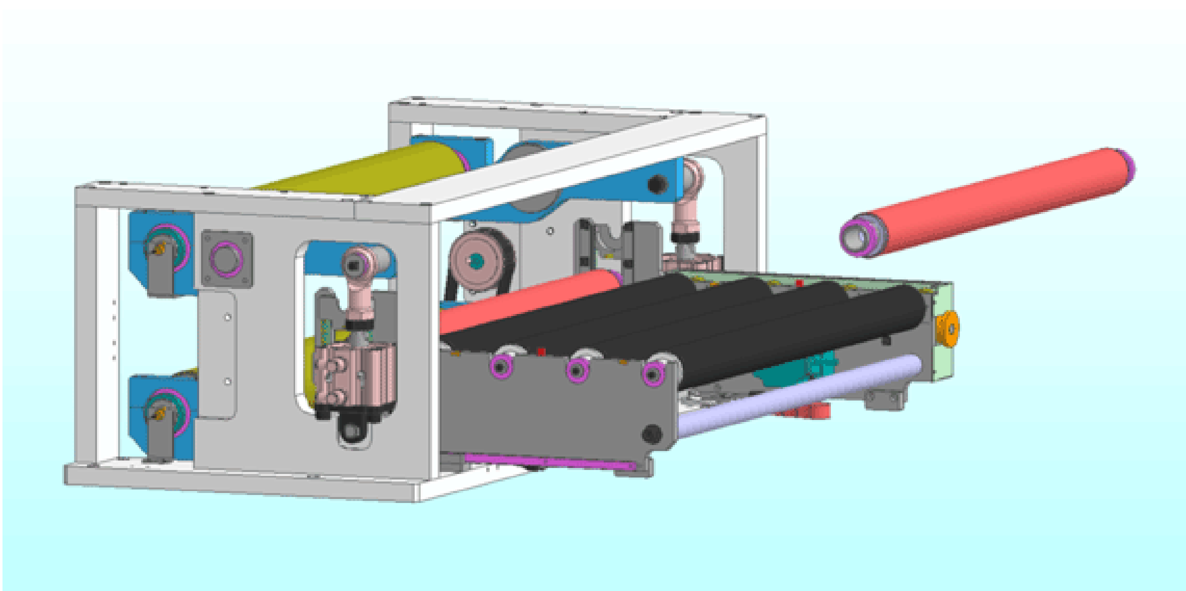


Figure 4: Pressure, temperature, and rubber roller module.

It is comforting to see that these types of innovations are helping the PCB packaging industry keep up with the most stringent requirements. This is not to say we have solved all the problems because the final PCB still has to wrestle with other issues like chemistry, drilling, registrations, etc., but we have come a long way in the imaging department from stick-on, taped artwork.

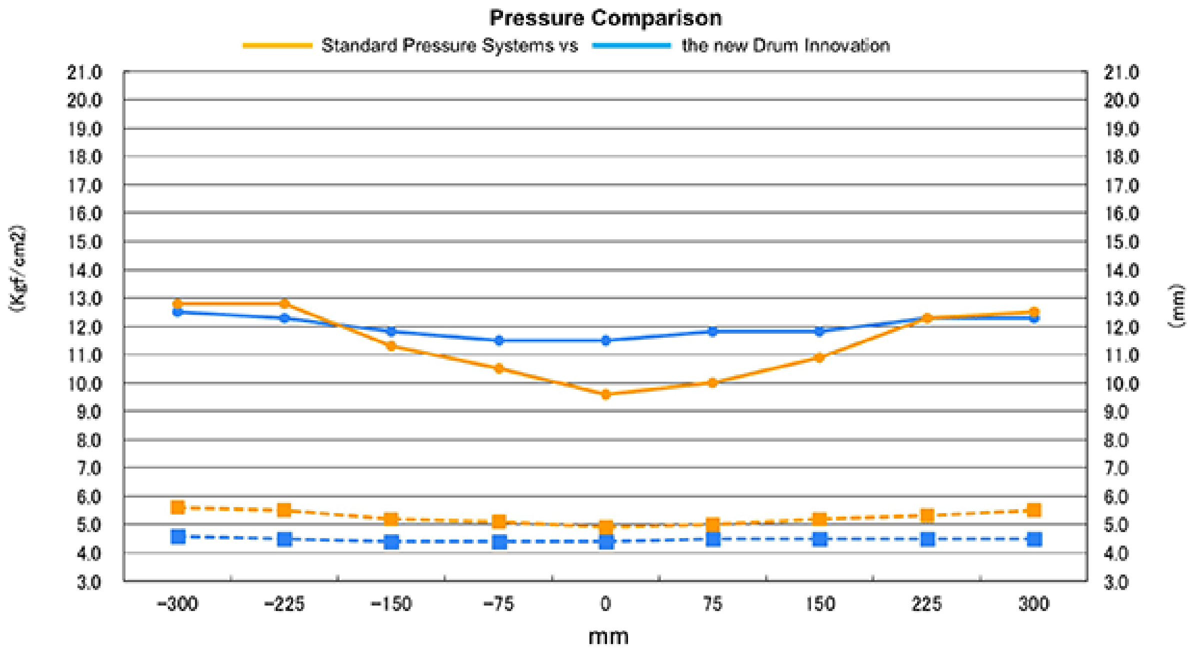


Figure 5: Comparison of the pressure results of standard hot roll mechanism to the new drum roller.

Figure 5 compares the pressure results of standard hot roll mechanism to the new drum roller.

There is a distinct difference in the pressure applied and the pressure profile results.

Currently, there are further and complex tests being performed on certain types of laminate and copper surfaces with various types of dry film. We hope to show how our industry is finally adapting to reaching a high level of success with micron features and overall optimal adhesion and attachment of dry film resist to varying copper surfaces.

Our next article will deal with the results of these tests. We will take an exhaustive look at the testing of certain types of dry film and certain types of laminates and copper to document the results of this new innovation. Because of the nature of the innovation, we are expecting outstanding results to transfer those micron features with very high yield.

Fred Long is in business development at Matrix Electronics. To contact Long, click here.

Reference

1. “Improving Dry Film Lamination Yields,” by Jeffery G. Stark, Sensor Products Inc. and Karl Dietz, *Printed Circuit Design and Fabrication*, Jun 2009.