isola

Application Note

Multilayer Lamination: Vacuum Frames

Written by Darrell Parsons
Isola

While the PCB industry as a whole has long recognized the value of performing multilayer lamination operations under vacuum, the specific method of achieving that vacuum varies.

A common method of introducing vacuum lamination to a facility that has a well-functioning hydraulic lamination press is to use “vacuum frames.” These frames allow the user to create an individual “vacuum” environment in any single press opening without any changes to the existing equipment.

When a user moves from a standard hydraulic lamination system to one utilizing vacuum frames, the expectation is that the change will result in fewer voids, better fill and bond, less image transfer and all at lower lamination pressure. The reality is that if you understand and work with the limitations of the system, you will get fewer voids and achieve better fill and bond, but not without a significantly lower pressure and probably not with less image transfer.

A vacuum frame system consists of a frame (usually aluminum) that is rectangular in shape and about one- inch thick. Both sides of this frame have “gaskets” in place. An outlet port for drawing a vacuum and usually a single (less often a multiple) double sided plug port for thermocouple wiring. The concept is to place the “booked” multilayer package inside the frame opening with solid plates in contact with the gaskets on both sides, pull a vacuum and apply heat and pressure in the normal lamination cycle. With a well-maintained frame system, the vacuum can be pulled “offline” from the lamination press and product maintained in a very low-pressure vacuum environment, a potential advantage with heavy copper inner layers or other designs that might be harder to fill. Not all resin systems will benefit from a long vacuum soak prior to lamination but some systems will benefit from the “drying” action that vacuum provides.

The real key to getting the benefit of a vacuum frame system is to understand that the dynamics of thermal and pressure transfer normally associated with a standard hydraulic lamination press is going to change when using vacuum frames.

Because frame is solid and the gaskets are limited in the ability to compress a narrow range of total stack height must be calculated and maintained without regard to the actual stack height of the product being laminated. The material used and how they are placed to achieve that “standard” stack height inside the frame will change the thermal transfer characteristics as well as how that stack height is calculated.

THE SINGLE MOST IMPORTANT FACTOR TO UNDERSTAND WHEN USING VACUUM FRAMES IS THE STACK HEIGHT CALCULATION, FOLLOWED BY UNDERSTANDING THE IMPACT THAT OTHER MATERIALS AND WHERE THEY ARE PLACED IN THE BOOK HAVE ON THERMAL TRANSFER.

Essentially, the stack height must be calculated on the “compressed” value of all materials, including the multilayer board being laminated. Fabricators that lay up product and add filler to achieve a stack height that appears to be appropriate for any individual frame, often find that as pressure and heat are applied in the lamination process. The combination of thickness reductions caused by evacuation of air, resin melt and fill and compression of pressure distribution pads results in a final stack height low enough that the “hard stop” provided by the metal frame and gaskets will prevent pressure transfer to the product inside the frame. As the “effective pressure” is reduced, thermal transfer efficiency falls dramatically, thus creating a situation where the product may not see adequate pressure or thermal transfer.

Isola offers a “stack height calculator,” based on vacuum frame dimensions, gasket thickness, multilayer board thickness and other materials. It should be noted that while newer gaskets provide significant resistance to pressure at lamination, after a few cycles could become soft enough that the stack height may need to be recalculated. The problem that many fabricators encounter is the difficulty in getting the outside plates to seal against “soft” gaskets because of the stack height in an “uncompressed” state.

The solution is usually to provide some mechanical aid to help compress the package while drawing a vacuum. Once the vacuum is in place, it is no longer a problem. Hydraulic or mechanical compression devices (clamps) are recommended to avoid situations where lay-up technicians are forced to reduce the correct stack height to allow a vacuum seal to be achieved.

You can expect the thermal transfer rate to be reduced even when using the same pressure as normally used in a non-vacuum hydraulic lamination system, part of that reduction in transfer rate is going to be a function of materials used to build the appropriate stack height and how they are placed inside the vacuum frame.

A book is commonly put together outside of the vacuum frame. It consists of several multilayer boards with separator plates of either stainless or aluminum with a stainless plate top and bottom. A pressure distribution pad (often compressible paper) is added and then an outside rigid plate with bushings. It is held in place with tooling pins of a length appropriate for any given stack height. The remainder of the calculated stack height can be anything, however avoid using paper, pads or laminate, as these materials will significantly slow thermal transfer. Metal plates are very effective for thermal and pressure transfer, but must be perfectly flat, as small air gaps can compromise transfer efficiency. This can usually be overcome by alternating metal plates with one ply of craft paper between plates, as more than one ply will slow thermal transfer. You may have to use a combination of thickness to achieve the desired stack height, as the total variation from minimum to maximum is usually no more than one-quarter inch.

Vacuum frames can be effective but are not something you can set and forget. It may take some work to get set up correctly and does require a commitment for regular monitoring and maintenance; however, it is certainly a valid alternative to a full-vacuum lamination press.