Benefits of Horizontal Desmear and Electroless Copper for High Technology PCB Manufacturing

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Abstract

Higher Technical Demands for PCBs means new processing challenges and to achieve reliable and consistent results requires improvements in current techniques. With this paper we will show the benefits of horizontal desmear and electroless copper processing for high technology applications including the latest results from development work.

Introduction

The technical benefits of horizontal processing for PCB production are well documented. The ability to achieve good fluid movement and exchange in through holes as well as blind microvias makes horizontal processing superior for high technology applications. Combining the almost identical processing of each board means highly reliable processing from board to board and with frequent dosing and process control from batch to batch. The superior flooding of horizontal systems compared to vertical systems allows for shorter process times and therefore higher productivity.

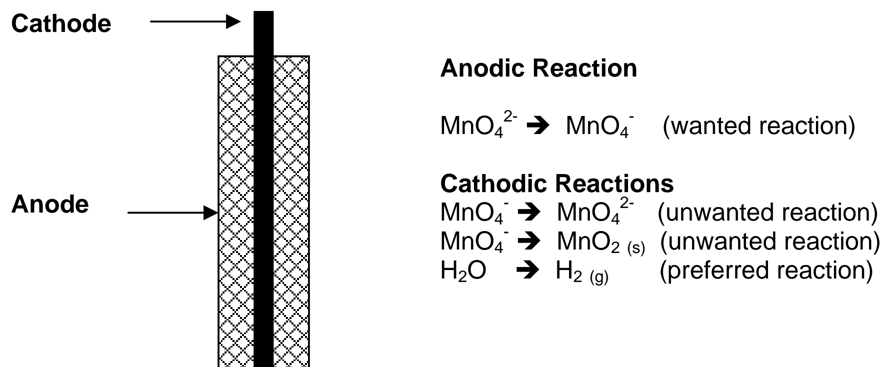
The latest horizontal equipment development from Atotech is called the UTS range, (Universal Transport System). This combines several advances in fluid delivery but mainly a cassette based transport system that can be replaced with different roller configurations to allow simple modification of a machine's transporting system for future panel requirements, so effectively future-proofing the machine.

Desmear

Developments in permanganate regeneration systems allow higher processing capacity as well as suitability for use for desmear intensive technologies like SAP (Semi-Additive Processing). Atotech has developed a new generation of regeneration cells and units that can increase manganate to permanganate regeneration by up to 100%. The new systems called Oxamat 3 for the cells and Oxamat 4 for the units have been designed to increase the regeneration effect whilst reducing the other negative side reactions.

The regeneration of manganate to permanganate occurs at the anode, whilst the negative reactions occur at the cathode. By increasing the effect at the anode and by inhibiting the negative reactions at the cathode so increasing the electrolysis of water we are able to dramatically increase the permanganate regeneration performance of the cell whilst maintaining the current flow.

Diagram 1 – Permanganate Regeneration Reactions



These new units mean that the number of cells required for regeneration is reduced by almost 50%. Combined with size reduction of the cells at no cost to performance we are able to fit almost twice as many cells in the same space. This gives a total possible reduction in area required for cells by over 350%. This means when applications like SAP are required, which generally require 10 times more regeneration capacity than for standard PTH (Plating Through Hole) boards, the increase in area required for the new regeneration cell types is only about 3 times. With the standard regeneration systems the large area required would mean massive and inefficient off-line tanks.

The uniformity of desmearing across a panel is very important to ensure good desmearing of through holes as well as blind microvias and for SAP applications. The capability of the new Uniplate equipment was tested using different laminate materials. Tests were made by processing desmear etch rate coupons through the line in a specially designed carrier panel.

Picture 1 – Carrier Panel with Desmear Etch Rate coupons

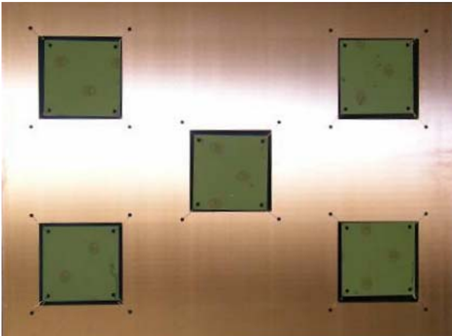


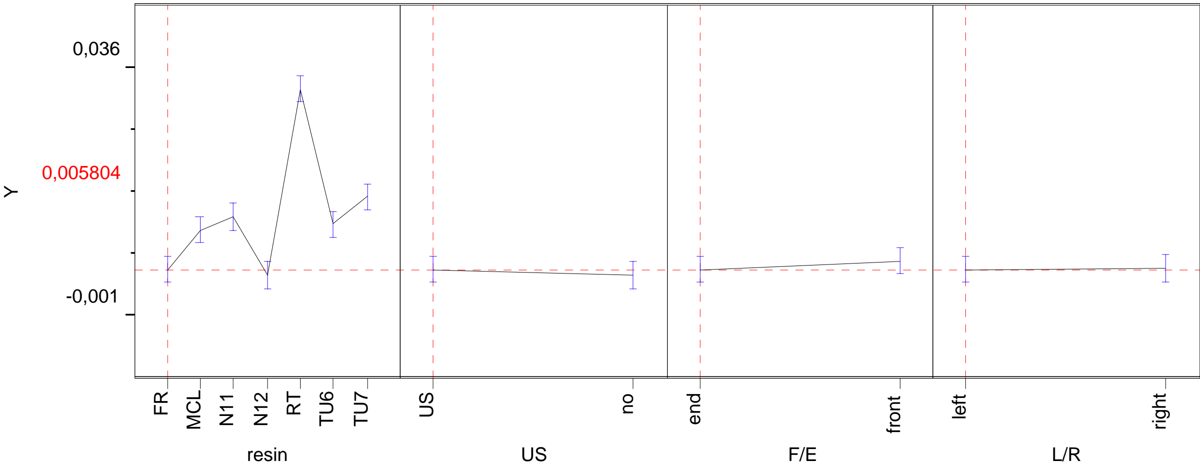
Table 1 – High Tg Laminate Materials Tested

Supplier	Material	Tg (°C)	Description
Isola	FR408	180	Pb-free, low loss
Hitachi	MCL-E-679W	177	Pb-free
Nelco	4000-11	170	Pb-free
Nelco	4000-12	180	Pb-free, low loss
Matsushita	R-1755C	175	Pb-free, v.low CTE
TUC	TU-622-5	145	Tetrafunctional
TUC	TU-722-7	175	Pb-free

As we wanted to see the influence of desmearing for newest technologies 7 laminate materials, most of which were lead-free capable, were chosen and tested.

Ultrasonic support has been used for a number of years to improve wetting as well as to increase weight loss or at least hole wall cleanliness. The effect of using ultrasonic support was determined for this entire set of materials. The difference in desmearing, judged by weight loss, was determined for coupons at the front of the panels compared to the back as well the left side versus the right-hand side. The results are:

Graph 1 – Desmear Results

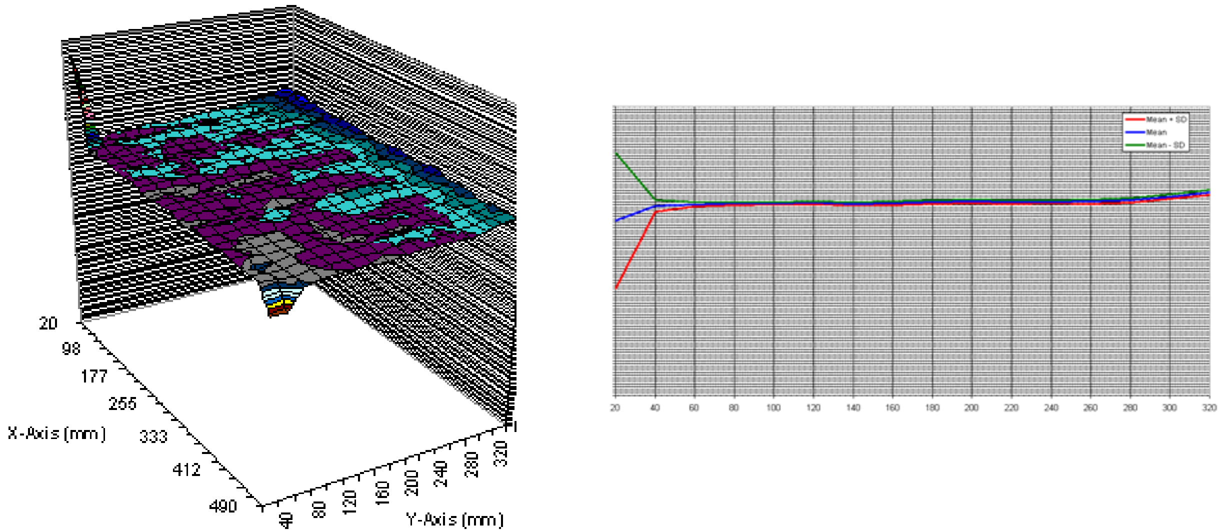


The results show a very low weight loss for most of the materials apart from the Matsushita R-1755C. The difference in weight loss for coupons front to back or left to right is very little, showing the even distribution of desmearing as expected for the superior flooding systems used in the Uniplate line. The average standard deviation is only about 8%. The influence of ultrasonic support for weight loss is surprisingly little and is due to the natural low weight loss for this set of high Tg, lead-free capable materials. Further testing did show that for distribution of weight loss the use of ultrasonic support reduces the variance even more from about 8% to 6% standard deviation, so giving a positive influence. For the very low weight loss materials like Isola FR408 and Nelco 4000-12 it was found that ultrasonic support increased weight loss by over 100%, so for extremely difficult materials ultrasonic support is extremely beneficial.

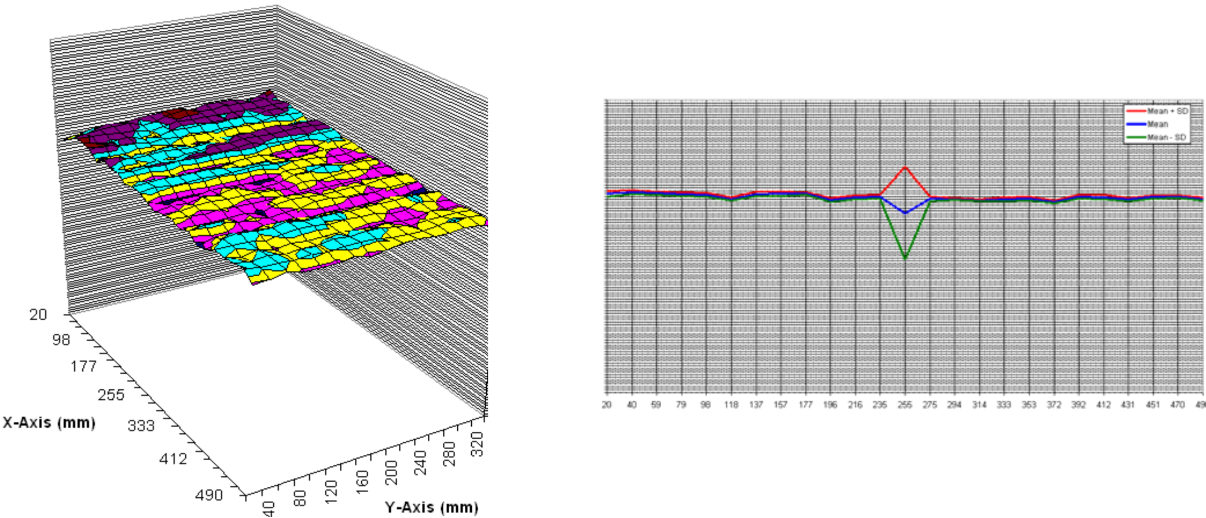
Microetch

The micro-etching process step is critical to ensure good quality copper interconnections especially for inner layers and blind microvia target pads. In general a micro-etching rate, as measured on surface foil copper, should be about 1.0 – 1.5 µm to ensure good interconnection quality. New manufacturing methods like modified-SAP, drilling techniques like direct CO_2 laser ablation as well as other fine line applications require a reduced surface copper foil thickness. With foil thicknesses already below 5µm and with expectations of 3 µm, or even 2 µm for specific applications, the uniformity of surface etching during processing is critical. The optimisation of the uniformity of the microetch is therefore necessary to ensure that there are no areas on the board that are excessively etched and that could cause bare patches whilst maintaining a suitably high etch rate for good innerlayer and target pad cleaning. Testing was performed where the foil copper thickness was accurately measured before and after etching to determine any differences between flooding system arrangements.

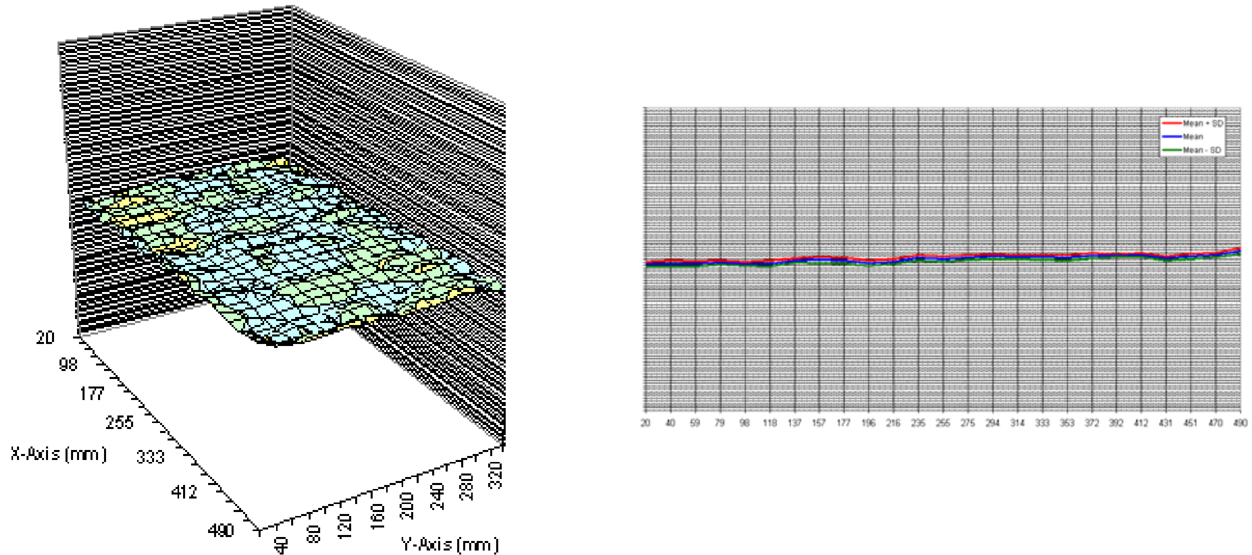
Graph 2 – Etch Results for Flooding System 1



Graph 3 – Etch Results for Flooding System 2



Graph 4 – Etch Results for Flooding System 3

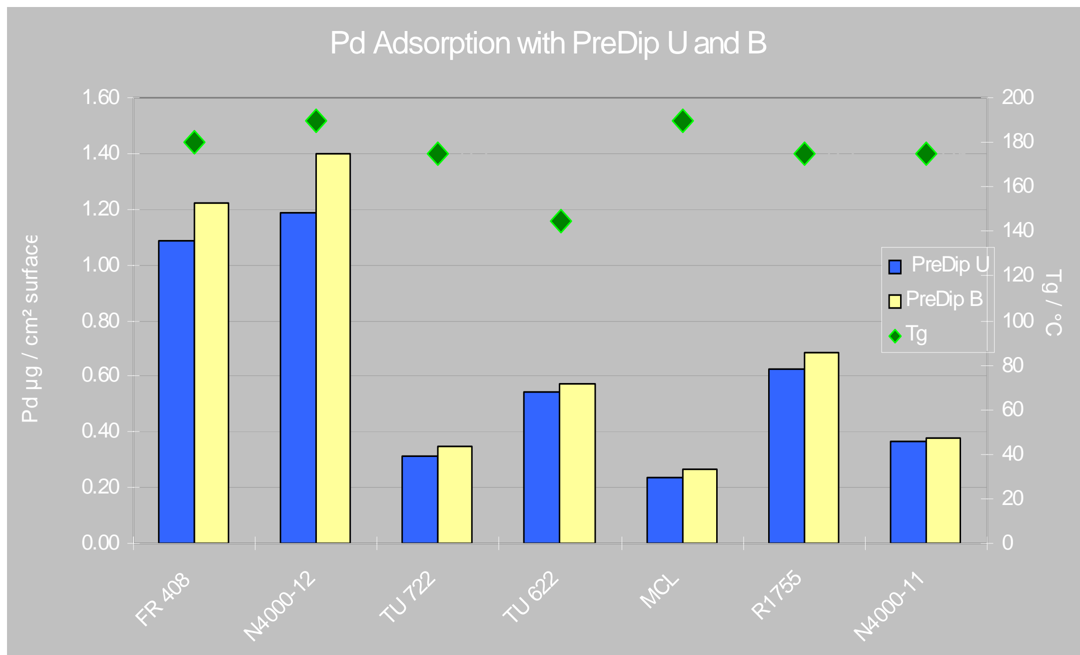


Flooding system 3 showed the least variance across the panel and so would the recommended set-up for processing. The maximum distribution of etching was about 10% across the whole panel. Further improvements are under development to reduce this deviation further as well as to assess the etching effect of innerlayers as well as capture pads.

Pre-treatment

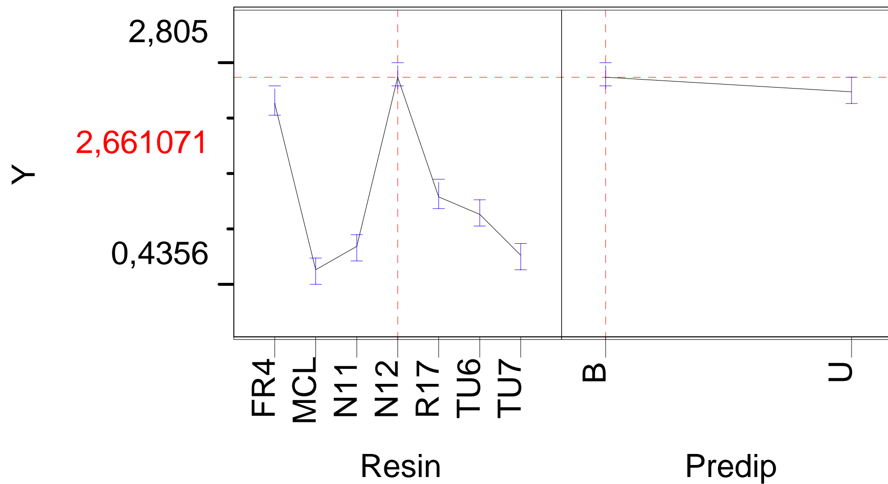
The influence of newer base materials on pre-treatment, especially on conditioning and palladium adsorption for the activation system is of major interest. The same lead-free base materials from the desmear tests have been tested horizontally to determine the differences in palladium adsorption as well as the influence of different pre-dips.

Graph 5 – Palladium Adsorption for Different Materials and Pre-treatment



There is a clear difference in the adsorption of Pd for the different materials. The FR408 and N4000-12 have high adsorption where as the rest of the materials show 50-80% less adsorption. The use of the pre-dip B system compared to U increases the adsorption of Pd by about 10%.

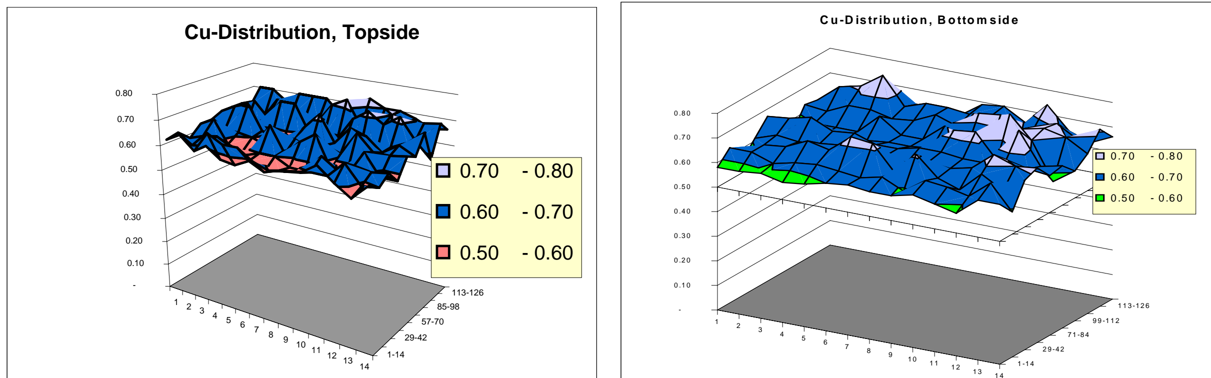
Graph 6 – Palladium Adsorption for Different Materials and Pre-treatment



Electroless Copper

An electroless copper should have benefits like fine crystal structure for good interconnection quality, superior hole wall adhesion and good throwing power so that high aspect ratio holes and blind microvias has reduced voids. Another critical step for advanced PCBs is the distribution of electroless copper deposited. For processes like SAP this is extremely important as the lines and spaces become thinner and the track profile and adhesion becomes more critical meaning that a lower electroless deposit is required. Using horizontal electroless equipment like UTS and specifically designed electroless copper chemistry like Printoganth SAP can help to reduce the required thickness from over 1µm on the surface to only 0.6 µm. With this thickness of electroless copper deposit the distribution is more important as we want as uniform a deposit thickness as possible over the entire board. This test was made to see the current capabilities of the UTS system and Printoganth chemistry for SAP application. Ajinomoto SAP laminate material was taken and processed without desmear through the electroless copper line and the thickness of deposit was analysed across the board.

Graphs 6 and 7 – Electroless Copper Distribution



The standard deviation for an average deposit thickness of 0.65 µm was about 6% for the bottom of the panel and 9% for the top. This is superior to vertical electroless, which is about 20-30% at 1 µm deposit thickness and with further variances between panels within a basket.

Conclusions

Horizontal desmearing and electroless copper processes have better capabilities than vertical processing for more demanding, high technology PCBs. Advances and developments in horizontal equipment and chemistry mean superior results for the emerging technologies resulting in higher yields. Further development and optimisation work is continuing for the exciting fields of horizontal SAP, M-SAP as well as for challenging through hole geometries of < 100 µm and blind microvia diameters < 50 µm.

Acknowledgements

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