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A Novel Conformal Back-Up Material and Process for Drilling Printed Circuit Boards

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Abstract
Interconnects between layers of circuitry in multilayer printed circuit boards are produced by drilling and plating. Drilling quality can have a major impact on the longevity of the plated interconnect. Mechanical drilling is especially challenged when the printed circuit board panel is not perfectly flat.

Many printed circuit boards (PCBs) contain components and features that create topography that is either expensive or impossible to level out during drilling and other manufacturing processes. A novel material and method have been developed, and benefits demonstrated, that is highly conformable providing a means to produce a level drilling surface without altering or negatively impacting the printed circuit board.

In summary, this paper will present a new technology and process in mechanical drill backing material designed to be used in rigid multilayer, rigid-flex and flexible printed circuits.   The features and benefits of the technology will be presented as well as examples showing method of use, a comparison to standard drilling methods and the resulting benefits of using this material.

Background of the Need for a Solution
Printed circuit boards are becoming ever more complex. Stacking of etched copper foil layers to form multilayer printed circuit boards are commonplace, but there is a trend to add more features and functionality. To do this, foil layers may have different thicknesses combined with mixed material types, such as rigid or flexible layers. All of this leads to increased topography of the printed circuit board surface.

Interconnections between the copper foil layers are done by drilling through and piercing the foil, followed by a deposition of copper metal (see Figure 1). This links the “web” of etch foil circuits vertically or more commonly referred to as the “z-axis”. It is very important that the drilled holes are free of defects that will become folds, crack or seams in the plating that could result in “opens” and circuit failure.

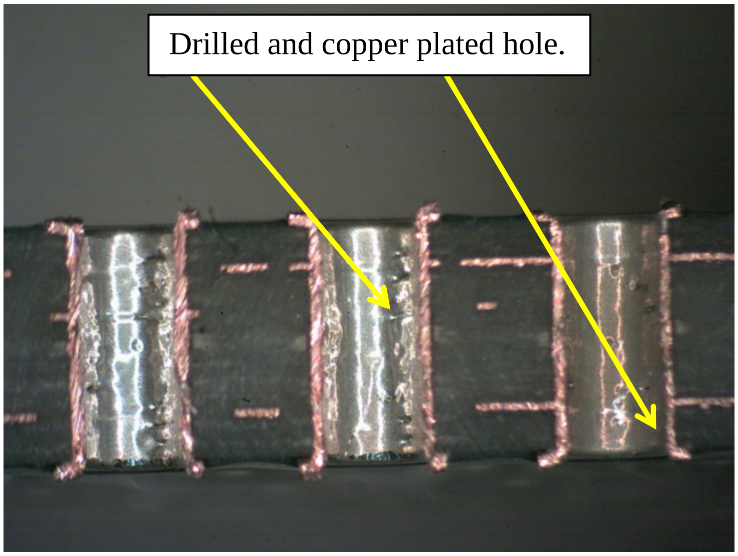

Figure 1 - Plated through hole cross section

Defects can occur in the plating from artifacts from the drilling process. Copper foil burrs (see Figure 2), gouges in the dielectric surface are some examples of drilling problems that lead to copper plating defects.

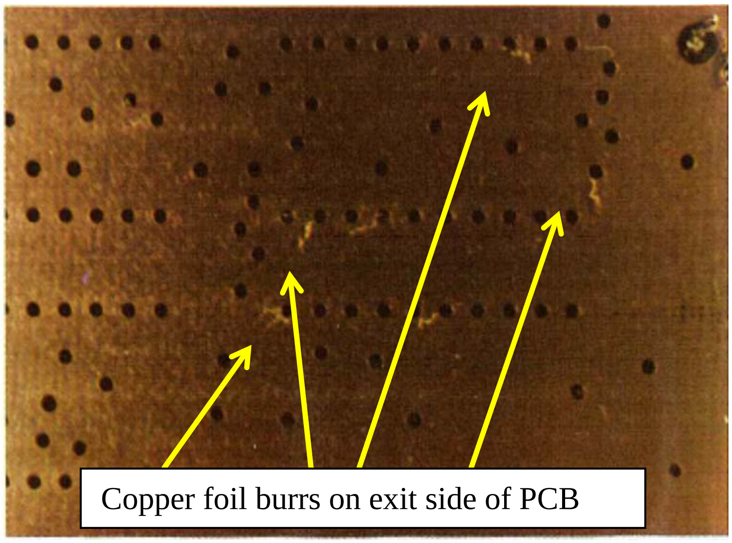

Figure 2 - Copper foil burrs

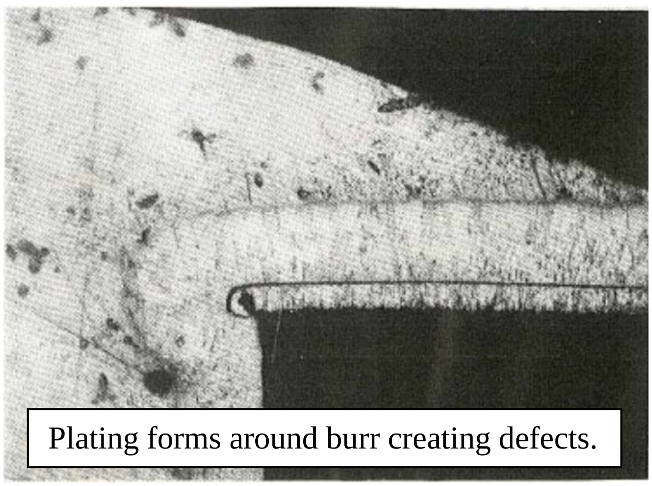

Figure 3 - Defect due to burr on exit

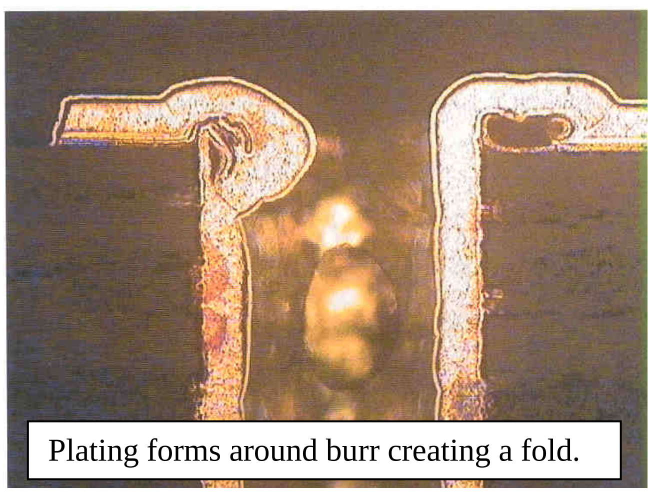

Figure 4 - Defect due to burr on exit side of drill

As the copper metal is electroplated around the burr, defects like plating folds, voids and seams can occur (see Figures 3 and 4). These can lead to a crack in the copper plating causing an open circuit.

Typically, a back-up material is used to minimize burrs by supporting the exit side copper. The back-up material is placed under the PCB prior to drilling.

Back-up material performs several important functions in PCB drilling:

First, the back-up acts as an offset lifting the PCB off the drill machine table. This gives the drill tool a material to drill in to after completely drilling through the PCB. This ensures complete drilling (penetration) of the PCB while preventing damage to the drill machine table.

Second, it provides support to the relatively soft copper surface foil on the back side of the PCB. This support and the hard surface of the back-up prevent the copper from burring.

Many PCB drill back-up materials will have a medium density wood fiber core with a top coat of some more uniform material on the top and bottom sides. Because the drill tool does not penetrate more than ½ through the back-up, the back-up is typically used on one side then flipped and used a second time. Some top coat examples are aluminum foil, epoxy coated paper, liquid epoxy resin coat, melamine and acrylic.

As stated above, the hard surface coatings on the back-up material help prevent burrs, while the soft core minimizes drill bit wear. However, if the PCB is not flat, burrs can be created when there is no contact between the exit side of the PCB copper and the drill back-up material (see Figure 5).

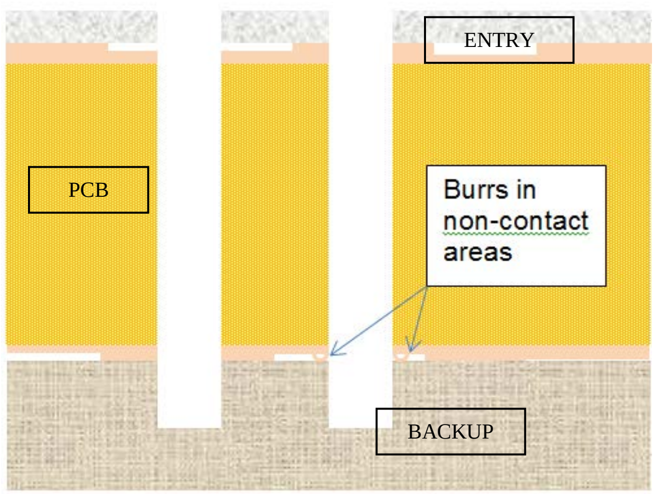

Figure 5 - Non Contact between PCB and Backup

Below (see Figure 6) is an example of a flexible PCB with internal layers of different thicknesses. This leads to a non-flat surface copper. Drilled with standard back-up, this PCB will require extensive manual rework to remove the burrs and prevent plating defects.

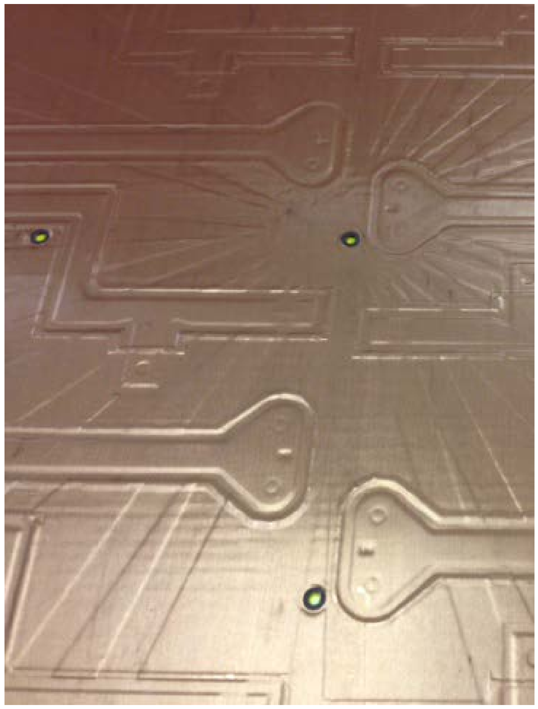
Figure 6 Non-Flat flexible PCB

Brief description Conformal Back-Up Material

The material structure provides a means to drill a wide variety of multilayer PCB constructions with varying surface topographies. It shapes itself to the PCB topography on one side, while staying flat on the other. It provides the support needed for copper burr suppression. In order to get these different and opposing properties from the material, a composite structure is employed.

The composite is composed of a core and a surface coating on each side. The choice and formulation of materials is critical to get the proper combination of properties. As an example, a liquid core cannot be used as this requires lateral displacement for changes in height. Conventional back-up is simply too hard and non-conforming to shape without damage to the PCB.

By using a 3 layer composite (see Figure 7) between the PCB and a standard back-up, the composite can shape itself to various topographies that may be present in a multilayer or rigid flex PCB. This allows the back-up to stay in intimate contact with the surface copper, reducing burrs.

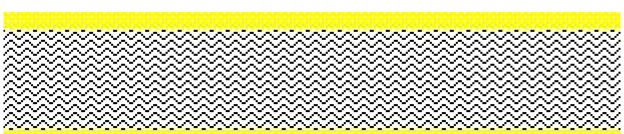

Figure 7 - Drawing of the Conformal Back-up

The product may be better understood with reference to the following example.

Example 1 – Conformal Back-up

A three layer structure with two layers of bonding adhesive.

1. An acrylic coated paper
    a. A thin adhesive bonding layer
    b. A low density paper fiber core
    c. A thin adhesive bonding layer
2. An acrylic coated paper

The picture below shows the conformal back-up (see Figure 8) in place after the conforming process.

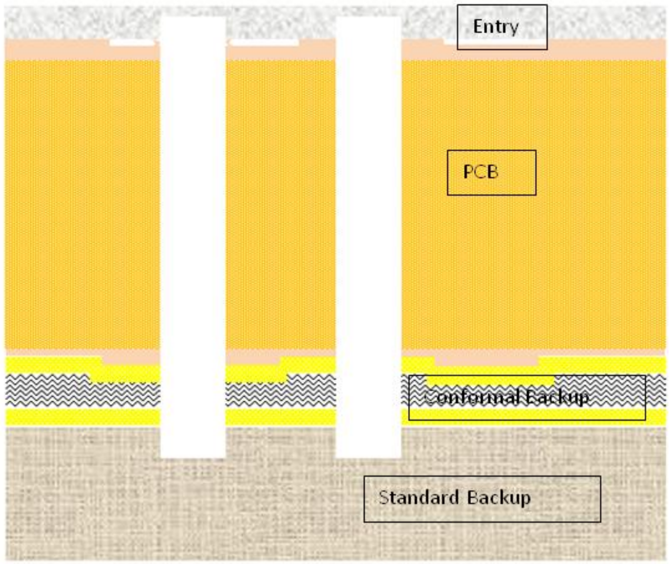

Figure 8 - Conformal Backup in place

Detailed Description of the Material

In the manufacturing process the conforming, composite core is used in combination with a shapeable surface coat. The coating must be able to bend and conform to the PCB surface while being hard enough to prevent copper burrs.

One key feature of the conformal backup material is to not use a wood, metal or plastic core, but one that contains air pockets such as low density paper, metal wool or polymer foam. This allows vertical displacement without lateral movement of the material.

The top coat may be a laminated film or foil, or a dried/cured liquid such as epoxy, acrylic, phenolic or melamine. The key feature here is that it can bend and retain its shape in response to heat, pressure or both. The amount of heat and pressure must be enough for shaping, but low enough not to harm the PCB structure.

Another key feature of the conformal backup is the top coat should have a room temperature hardness of 30 to 90 on a Shore “D” Durometer scale.

The core and the top coat are bonded to one or both sides to make a composite that is attached to the PCB and shaped prior to drilling.

It must do two things: it cannot reduce the composites ability to conform and it must not impart any contaminates into the PCB that will interfere with copper plating.

Conclusions

High topography printed circuits require a backing material to minimize drill burring in order to improve yields in downstream processes.

The newly developed conformal back-up material has conformance characteristics and performance properties that demonstrate the ability to minimize drill burring on high topography printed circuits. See Figure 9 and Figure 10 for results of exit burr reduction using the conformal backup.

The materials used will not contaminate the drilled hole and any debris from the drill process is removed using standard cleaning methods already used at the PCB manufacturer.

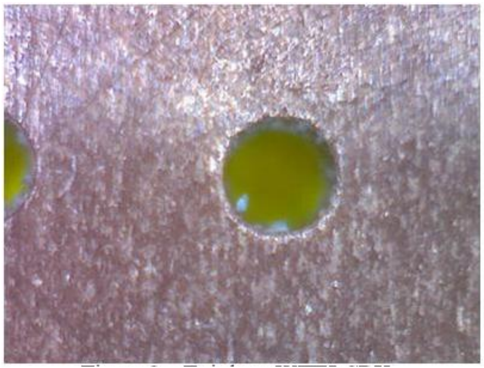

Figure 9- Exit burr with CBU

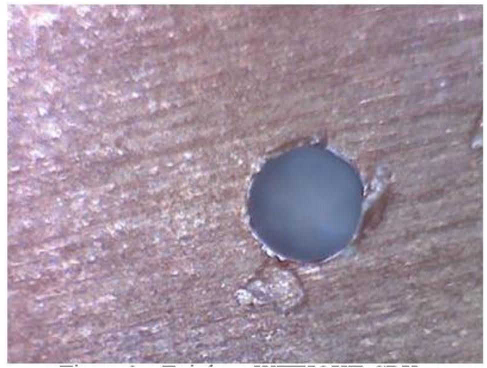

Figure 10- Exit burr without CBU