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Component Whisker Mitigation, p. 36

PRINTED CIRCUIT DESIGN & FAB / CIRCUITS ASSEMBLY

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WHICH ONE IS FAKE?

Silicone Conformal Coatings

CAD-to-CAM Data Transfer Case Study

Flex Circuit Outer Layer Planes

Copper or Epoxy?

For outer layer planes, the decision comes down to when the "bend" will occur.

QUESTION: I AM designing a flexible printed circuit board, and I need planes on the outer layers. I also need it to be very flexible because I have to bend the circuit sharply at several locations. Am I better off using copper or conductive epoxy for my plane layers?

Answer: Depending on the exact application, you may be able to use either copper or conductive epoxy and still end up with a reliable circuit. Everything else being equal, the conductive epoxy version will typically yield a more flexible end product than the copper version. That does not mean that copper may not still be the best choice for your application. Multiple copper planes on a flex circuit will give the circuit a lot of memory, which is advantageous if you plan to pre-form the circuit prior to installation. If the installation operator is making the bends as the circuit is installed, the conductive epoxy version would probably be a better choice. There also are newer options available for making plane layers on a flex circuit. Here are the "pros" and "cons" of each material.

FIGURE 1. Copper planes can be cross-hatched to increase flexibility.

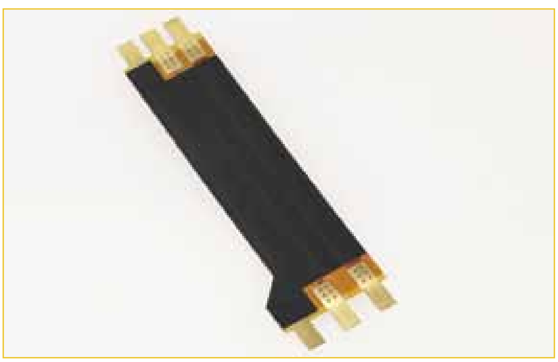

FIGURE 2. Conductive films (black area) combine a conductive layer with a protective cover and bonding adhesive in a single laminate.

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Copper "pros."

- Copper is the time-proven material used for plane layers on flex circuits. It has very good conductivity, and can be easily connected to other planes and internal conductors using plated vias.
- Copper has a lot of memory, so pre-forms will hold their shape nicely.

Copper "cons."

- Using copper for plane layers will yield the thickest (and therefore stiffest) construction. Considering that plane layers usually end up on the outer layers on flex, they may also end up with an additional layer of copper plating, making the circuit even stiffer. Fabricators can etch a cross-hatch pattern (FIGURE 1) into the outer layers to improve flexibility, but unless you are removing 80%-plus of the copper, I have found that the added flexibility is minimal. For controlled impedance, a cross-hatch pattern may have unpredictable effects on high-speed signals.

Conductive epoxy "pros."

- Silver epoxy is the most common conductive epoxy used in shielding and plane applications on flex circuits. It has very good conductivity, and I have found that electrically it performs very close to copper.
- Using conductive epoxy for plane layers will result in a considerably more flexible circuit than one built using copper for the plane layers.
- Interconnection between layers is possible and does not require any additional plating to accomplish this.

Conductive epoxy "cons."

- Conductive epoxy has little to no memory and will not hold a form. Unless there is a significant amount of copper on internal layers to help hold the form, pre-forming may not be an option.
- Interconnecting the outer plane layers has to be done by connecting one plane to an internal conductor, which in turn is connected to the other plane. To ensure good interconnection, redundant vias are usually employed. Since you do **not** want to bend the circuit anywhere near an interconnection via, having multiple vias can limit the areas you can bend or form the circuit.
- Conductive epoxy is generally applied using screen-printing. For this reason, the edges will not be as well-defined, and there may be registration issues.
- Since one of the main ingredients is silver, the raw

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is normally photoinitiated and proceeds via a very rapid step-growth mechanism; an idealized outline of the initiation – propagation – chain-transfer reactions is shown in **FIGURE 2**.

In addition to the polymerization reactions discussed earlier, the thiolene reaction may also be used as a cross-linking mechanism. High molecular weight, vinyl functional polymers may be cured with short-chain, or monomeric, multi-functional thiolene curing agents via the same photoinitiated reaction. It is essentially an addition reaction, so no byproducts are produced, and shrinkage is low. There are hundreds of vinyl and thiol combinations. Vinyl functional polydimethylsiloxanes are abundant and readily available, and there is a fairly wide selection of short-chain mercapto-functional polysiloxanes. This combination may be employed to produce UV-cured silicones.[2,3] These systems were originally investigated as possible release agents for paper coatings.

This chemistry has been extended to include a secondary moisture reaction for curing in shadow areas and to further increase cure strength, adhesion and system dynamics.[4] Clear materials based on this new system are much more robust and cure to greater depths with much lower energy requirements than conventional acrylated silicones. This translates to increased processing speeds and faster turnaround. Essential for protecting electronic circuitry and significantly extending the service life of printed circuit boards, conformal coatings are an integral component of the entire sub-assembly. Eliminating moisture and contamination is a key element for protecting sensitive electronics. Silicone conformal coatings provide an effective barrier, even under the most severe service conditions. Now UV-cured conformal coatings that offer all the enhanced performance characteristics of conventional silicone-based materials, but with higher processing speeds, are available.

Perhaps more important, these new UV-cure, silicone resins may be filled, which means pigmented and even electrically conductive UV-cure silicone products are now possible. Flexible and printed electronics (FPE) incorporate several new technologies and emerging processes and materials across a variety of applications. FPE may be twisted, bent or shaped without damage, enabling endless innovation and unlimited possibilities.

When an application requires performance, durability and physical properties, a silicone-based product is the superior choice. No other chemistry provides the environmental resistance and performance at thermal extremes. While it is true that silicones are critical for applications under the most severe and harsh conditions, it is also true that the enhanced adhesion, increased flexibility and UV and moisture resistance are important for many less-demanding applications. **PCD&F**

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material is extremely expensive. The vendor may well use hundreds of dollars of silver epoxy just to flood the screen prior to running the parts. This can result in a cost premium for the circuits.

Some flexible conductive films are used regularly in lieu of copper or conductive epoxies in shielding applications. These materials are "all-in-one" solutions that combine the conductive layer, bonding adhesive and protective cover material in a single laminate (**FIGURE 2**). These materials provide a very flexible finished product. Interconnections between layers are possible and are made in a similar manner as the conductive epoxies. These materials are moderately priced and can be used with the manufacturer's standard processing equipment, so you will not "break the bank."

As always, I recommend you contact your manufacturer (during the design stage) for advice on which shielding options would work best for your particular application. They are aware of the strengths and weaknesses of each material and can steer you to the material that will give you the best chance of success. **PCD&F**