Adhesiveless Flex Substrates

The whys and hews.

Jerome Sallo

Flex circuits have entered many market areas since the introduction of adhesiveless substrates. Two factors are driving the demand for these materials. The main factor is the recent mil-spec change that eliminated the requirement for adhesives in flex circuits substrates. The other is the increasing need for commercial flex circuits for use in applications such as computers, communications, and automotive manufacturing. The adhesiveless polyimide/copper flex substrates fit into both scenarios and also meet worldwide demands for smaller, thinner, lighter end products.

The absence of adhesive and the use of very thin copper reduces the adhesiveless product's weight, an important issue in newer miniaturization technologies. Without the adhesive, flex circuits will pass the UL VO flammability specification, making them more suitable for high-temperature applications, such as under-the-hood environments. Also, adhesiveless materials are readily laser and plasma ablatable and in some cases can be chemically etched, allowing for very small via holes. These materials are more flexible and have a much lower Z-axis expansion rate than their predecessors.

Types of Adhesiveness Materials

In the first method of manufacturing an adhesiveless flex substrate, electrodeposited (ED) or rolled/annealed (RA) copper foil is coated with a polyimide film to form the composite. The thinnest copper typically available is 1/2 oz. This inherently single-sided material is made into a two-sided substrate when two single-sided layers arc bonded together with bond-ply or prepreg. Since the composite must be heated to the polyimide curing temperature during the coating process, the thermal coefficient of expansion (CTE) mismatch between polyimide and copper may induce stress in the structure. To combat this problem, a more heavily cross-linked and less-flexible generation of polyamides was developed. Even so, the X-, Y-dimensional stability of this type of construction tends to be less than that of materials based on hi-axially oriented polyimide films.

In the second adhesiveless manufacturing process, a hi-axially oriented polyimide film is coated with a high-temperature thermoplastic polyimide adhesive. High-temperature lamination with ED or RA copper foil, typically 1/2 oz., polymerizes the polyamides and completes the composite, whose minimum thickness is generally 2 roils.

The third approach begins with a hi-axially oriented polyimide film that is made conductive by the application of extremely thin copper film via evaporation, vacuum sputtering, or electroless copper deposition. Electrolytic plating builds the film on each side of the laminate to a thickness of up to 2 oz. A potential advantage of this type of construction is that the polyimide film can be punched prior to copper application, thus permitting PTHs to be made in the substrate during electroplating.

Because of its need for ductility, the flex industry has historically favored RA copper. However, recent fatigue ductility testing has shown that newly developed ED copper metallurgies are equal to or even superior to RA copper products. Another potential advantage of ED foils is that very thin copper can be used, which extends the fatigue life of products needed for millions of flexure cycles.

The emergence of these adhesiveless flex substrates has also caused the industry to rethink its position on bond ply and covercoat. The use of conventional adhesives has resulted in excessive Z-axis expansion, drill smear, excessive thickness, and other problems associated with the adhesives. One method of covercoat application uses a liquid photoimageable polyimide that is screened onto the flex circuit. This material could replace a variety of existing covercoat materials to augment the widening choices in adhesiveless flex substrates. FAB

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