Flexpert Flexible Circuit vs. Membrane

The "right" choice pits price versus performance.

QUESTION: WHAT IS the difference between a flexible circuit and a membrane circuit? Are they both considered flexible circuits? How do I know which to choose for my application?

Answer: Historically, the term "flexible circuit" or "flex circuit" has implied a circuit with photo-etched metal conductors (generally copper) on a film substrate (generally polyimide). Many of the manufacturing processes involved in building flexible circuits are very similar to those used in manufacturing rigid printed circuit boards. The main difference is that virtually all the insulating and bonding materials used to make flexible circuits are much thinner and generally unreinforced (films), as opposed to the glass-reinforced laminates used to construct rigid PCBs. The term "membrane circuit," on the other hand, typically refers to a circuit that has *printed* conductors (usually screen-printed) formed using conductive inks. Membrane circuits are created using additive processes, whereby all conductive and insulating materials are added in layers to the base material. Many conductive inks can be used to create the conductive patterns, but most rely on silver as the conductive component. The base insulating materials that membrane circuits are printed onto are typically polyester films.

Determining which of these variants is best really depends on the application and how the circuit will be processed and used. The decision to use membrane circuits is typically driven by cost. Polyester materials are much less expensive than polyimide, and the cost of forming silver ink conductors is significantly less than the photoetching process required to form copper conductors.

However, with reduced cost come many significant limitations. Polyester materials cannot tolerate the high temperatures that polyimide can withstand. For this reason, the upper service temperature will be limited to under 105°C with PEN, and even lower with other polyester materials. When screen-printing conductors, it is not possible to define features as small as can be done with photo-etching. For this

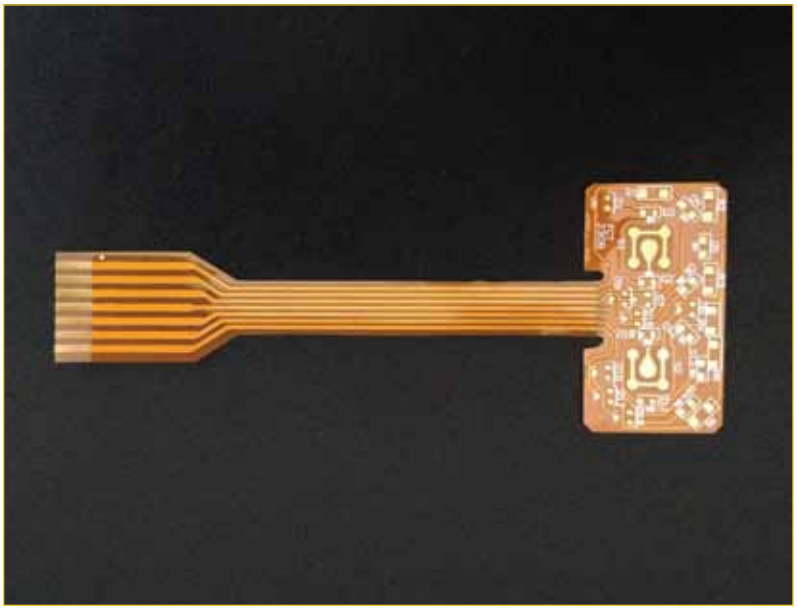

FIGURE 1. A standard copper flex. This is typically the best choice when the application requires soldered SMT components, high current or high temperature.

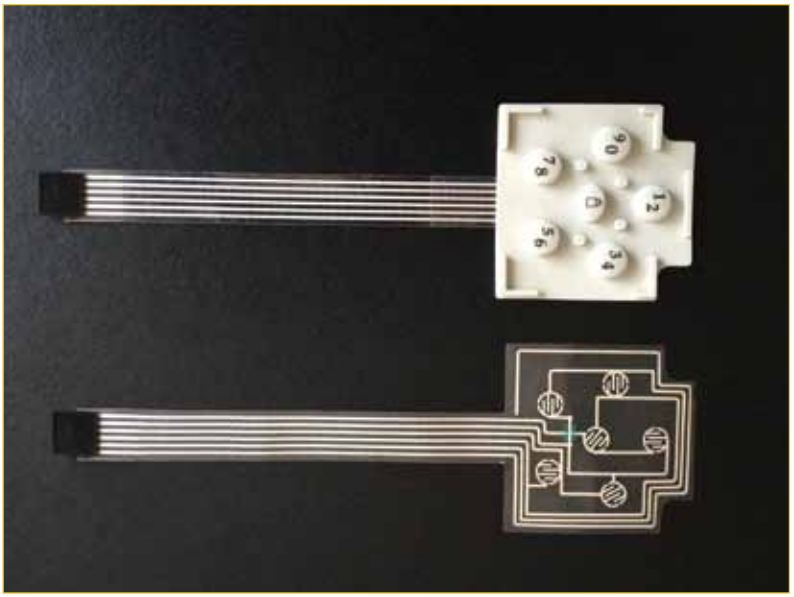

FIGURE 2. Typical membrane applications include keyboards and displays like the one shown here and other low-temp and low-current uses.

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reason, the wiring density of membrane circuits is significantly less than photoetched polyimide/copper flex circuits. Connections to connectors and SMT components are typically limited to ZIF style connectors, insulation displacement contacts, or silver ink in lieu of solder to attach components. Silver conductors are designed to handle small signals, so electrical current must be limited to 100 MA or so. Last, the additive processes used to create a membrane circuit limit the construction to a just a few layers. The vast majority of membranes in use right now are just one or two layers, with a very small number that add another two to three layers. Since it is not possible to use copper plating to interconnect layers, the layer connections are made by forming openings in the dielectric layers that permit the conductive ink from one layer to connect to the layer above or below.

As stated, copper/polyimide flex circuits are more expensive than polyester membrane circuits. But with the added cost come additional improvements in capabilities and performance in some important areas. For instance, most flex circuit manufacturers can easily make copper/polyimide circuits with 8-plus conductive layers. In addition to the extra layer capability, many vendors can supply circuits with conductor widths and spaces that are well below 5 mils. This results in the ability to pack much higher wiring density into the same amount of space as a comparably sized membrane circuit. If even higher wiring density is required, the flex circuit manufacturer can move to a rigid-flex design, permitting the layer count to increase to 20-plus conductive layers. (Caveat: 20-plus layer rigid-flex circuits are *really* expensive.) The other significant benefit of copper/polyimide flex over a membrane circuit is a much higher temperature rating. While a flex circuit will not tolerate temperatures as high as those a rigid PCB is capable of, they *can* withstand soldering temperatures for short periods of time. This permits connectors and components to be assembled using standard pick-and-place and reflow equipment to populate the circuits. And copper/polyimide flex circuits can operate for extended periods at temperatures well above what a membrane circuit can tolerate. Finally, copper conductors can carry vastly more electrical current than similar-sized silver conductors.

When weighing options in choosing your flexible interconnect, consider cost and also performance factors to determine the best fit for your application. Membrane circuits and copper/polyimide circuits occupy their own unique niches in electronics interconnection. Choosing the right one for your application will ensure the best overall value. As always, do not hesitate to contact your friendly neighborhood flex circuit (or membrane circuit) manufacturer for advice. Having seen thousands of applications, they are uniquely qualified to guide you to the right choice. PCD&F