Let's Hear it for Groovy Circuit Mechanics

Ken Gilleo, PhD – ET-Trends

We chemists appear to grab all the credit for circuitry processes. Sure, there's a lot of chemistry (some say chemical warfare) going on in the printed circuit plants. And chemists have delivered etching, plating, cleaning, and some splendid materials, and made all kinds of valuable contributions to the printed circuit industry. But what about those innovators with a mechanical inclination? Surely there must be some good mechanical circuitry processes. Well, it turns out that the very first documented circuit inventor, Albert Hanson (British Patent 4,681 filed in 1903), hit upon the idea of cutting out or die stamping metal circuit patterns. He glued them to dielectric to make both single- and double-sided circuits. The concept of cutting out copper circuit patterns may be a century old, but the automotive industry used a die-cut process to produce hundreds of millions of instrument cluster circuits starting in the 1960s or there about. Let's look beyond cut-and paste circuits for more advanced mechanical methods.

Why not form grooves in a dielectric substrate and fill them with conductive material? This principle has worked well for artists who have crafted grooves into a variety of substrates and filled them with inks, paints and other decorative materials to make fine-detailed patterns. Circuitry's newer groove-and-fill concept dates back to the 1920s. Circuit pioneers used all kinds of machining methods to form grooves in boards. The grooves could then be filled with conductive pastes and fusible alloys, or flame-sprayed with metal to form the circuit conductors. The scheme of using solder to form conductors brought a second benefit of having joining material already in place for assembly. This principle of a dual-purpose conductor was explored and tested by several companies in the early years and it still has merit.

But it didn't take long before the chemists tried to horn into the groove. Subtractive chemical etching can make grooves; one can etch many dielectrics including polyimide circuit substrate. The more popular approach, however, was to utilize additive processes. Photoimagable films and coatings were applied to substrate. Next, the material was exposed and developed to form fine pitch patterns of grooves or channels. The most common groove-filling methods were mechanical. One could knife coat or doctor blade conductive paste into the grooves. Some tried solder while others used conductive adhesives. Solder had the problem of not wetting the dielectric so adhesives became the focus. But no matter how smooth the dielectric surface, some conductive filler particles remained and had to be removed in a separate step. Most resorted to a mechanical grinding, or polishing, step to remove surface contamination such as hardened silver-filled epoxy that was a popular groove filler.

Perhaps the most recent attempt to use a groove-and-fill method was that of Poly-Flex Circuits (a Parlex company). During the 1980s, the company developed "Poly Channel" circuits and filled the grooves with Poly-Solder, a conductive adhesive designed specifically for SMT. Experts in screen printing and stenciling, the company invented a multi-blade squeegee to try and remove trace amounts of their silver-based adhesive. The extra blades worked fairly well and eliminated mechanical grinding provided everything was just right. Components could be placed into the uncured adhesive followed by thermal curing of the adhesive. Circuit fabrication and assembly had to be combined but there was no logistics issue since Poly-Flex made and assembled their PTF (Polymer Thick Film) products under one roof. The complete process involved forming grooves (photo, laser, or mechanical routing), filling with a stencil printer, placing components, and curing the circuit-assembly. Such simplicity is appealing.

Do mechanically-fabricated circuits make sense today? Perhaps! We are now in the age of Nanotechnology where we can "machine" and manipulate matter at the atomic scale. IBM wrote their initials by "picking and placing" atoms more than ten years ago. Dip Pen Nanolithography from NanoInk employs a pen to draw lines down to 15 nm or even less and the ink can be conductive. Fluid jetting is also accurate and versatile. Lasers that rapidly drill microvias could also make grooves. Very fine pitch grooves can now be embossed using methods developed for MEMS and optics. We are now at a level of technology where grooves, vias and other geometric shapes can be accurately fabricated. So perhaps we should take another look at mechanical circuit processes. Let's hear some thoughts from the mechanical fraternity.

Ken Gilleo
ken@gilleo.us
Dr. Ken Gilleo is the CEO of ET-Trends LLC, a consulting, electronic packaging design, and IP firm dedicated to discovering, analyzing and creating Emerging Technologies. Ken's present focus is on molded thermoplastic hermetic packaging for MEMS, MOEMS, displays and Nanoelectronics. He is also an experienced Expert Witness.