Circuits Unusual -- Ken Gilleo
by Ken Gilleo
September 1, 2003

Time to Bring Back 3D Molded Circuits?

PLASTIC IN YOUR FUTURE?

During a luncheon meeting with plastics innovator John Harker and associates, we discussed new trends in the injection molding field. Harker is CEO of Matrix Inc., a high-tech plastics fabrication company specializing in "insert molding." Injection molding entails pumping molten thermoplastic into multiple-cavity molds, cooling it to a solid, and ejecting the finished parts. Insert molding requires placing parts, typically metal, into empty mold cavities so that the injected plastic traps the inserted pieces to produce combination parts. Matrix does this all automatically with robotic lines. But these molding specialists wanted to know the best way to add metal to the surface of the plastic parts. This was a curious question from experts mating metal with plastic. Delving deeper, it turned out that customers were asking about adding circuitry to plastic parts.

Flashback!

We have jumped back to 1985 to explore the Molded Circuit Board (MCB) Revolution. Companies are working on processes to form circuits in 3D plastic parts. Some want lower cost circuit methods, but many are after 3D. Utilizing volume, not just area, makes sense and its worked well for the flex circuit industry.

In the mid-1980s, the "Molded Circuit Revolution" was just starting and sales were already projected to reach $450 to $500 million by 1990 [1] and the market share could end up at 60% [2]. It didn't happen, but good technology was created as companies developed unusual circuit processes for MCBs. Bell Labs was one of the earliest MCB developers. Their approach was to use photosensitive copper complexes that produced metallic copper where struck by UV. The copper pattern could be plated up [3].

PCK Kollmorgan developed a number of molded circuit processes like Tekmold™ and Kolmold™. The emphasis was on electroless plating, but several masking methods were used, including screen printing and photoimaging. Their Mold 'n Plate system molded catalyzed resin into circuit patterns using a two-step, double-shot molding process. The plastics industry has long-used "double-shot" molding for two-color parts. Ordinary resin was used for the circuit dielectric and plastic with plating catalyst formed the circuit patterning section. Now just place the activated plastic part into an electroless copper-plating bath. Their MCB technology was licensed to several companies, including Kodak, whose Pathtek division produced some MCBs in late 1987.

Semiadditive processes were also explored. The APE (Additive Plate N' Etch) process applied catalyst to the surface of the molded part. The plastic part was then plated with electroless copper

to deposit about 0.1 mil (2.5µ) of metal. Now apply, expose, and develop a plating resist, electroplate copper in the exposed area, strip the mask, and etch away the thin background "seed" copper.

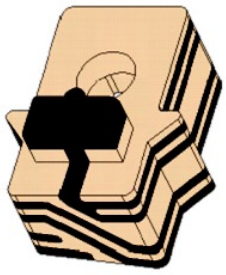
A number of other processes were developed that were unusual. The ADAP (Amphenol Dry Additive Process) system used a mold with recesses, or channels, for the desired conductor pattern. Special copper flake was loaded into the channels to form a copper circuit using a thermal compression bonding with an embossing tool.

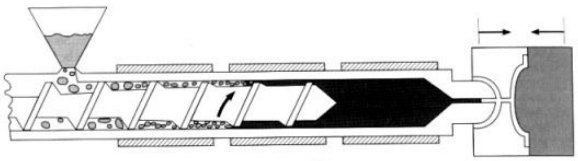
Elite Circuits developed Mint-Pac (Molded INTerconnection PACkages where channels were molded corresponding to the intended conductor pattern. Electroless copper was plated over the entire part including the channels. Liquid resist was roll-coated over the PCB leaving the recessed channels unprotected. Copper was plated into the exposed channels, the resist stripped, and thin "seed" copper was flash etched away. DuPont later bought Elite.

The Konec™ process from Chomerics (Seriglif) used Polymer Thick Film (PTF). Silver conductive ink was printed onto release paper then over-coated with primer. The circuit-patterned paper was inserted into the mold cavity and "shot" with resin. The part was ejected from the mold and the paper peeled away leaving the circuit. Clever, but why not in-mold a real circuit? Allen-Bradley used a flexible circuit insert-mold process that had appeal because circuit making and plastic molding were left to these respective industries. But insert-molding of conductors was already well established. Capsonic (Elgin, IL) had built an entire business on insert molding metal conductors into plastics. While most in-molded conductors were stamped metal, flex circuits were also mated to plastic. In 1961, IBM disclosed insert molding flex circuits in plastic molds [4].

Where Do We Go from Here?

Should we try to bring back 3D molded circuits and would it be successful today? Perhaps! Designers now think 3D, and that includes the packaging field. And since circuitry and packaging seem to be merging there could be synergy. Packaging specialists are investigating injection molding to replace traditional thermoset transfer molding and expensive ceramic and metal hermetic cavity packages. What's more, halogens are under attack, and brominated epoxy molding compounds (EMC) could be banned. Several high-temperature injection molding plastics can pass V-O without adding flame retardants—no halogen, no phosphorus and their dielectric constants are relatively low (3.0 to 3.5). So the time may be right to bring back molded circuits and champion molded packages. What do you think?





Ken Gilleo

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. Contact Ken: Ken@ET-Trends.com

References

1. Ganjei, J. and Frisch, D, "Mold Your Own?," *Circ. Mfg.*, pp. 39 - 40, 42 - 45, June 1986.

2. Wood, A. S., "Molded Circuit Boards: Emerging Technology for Thermoplastics," *Modern Plastics*, pp. 30 - 33, July 1985.

3. Manzione, L., "Molded PC Boards: New Way to Fuse Function, Form," *Plastics World*, pp. 57 - 59, October 1983.

4. Radovsky, D., "Preparing Molded Circuits", IBM Technical Disclosure Bulletin, Vol. 4 No. 3, August 1961.