Tech Talk

Fine Lines in High Yield (Part CLX)

Fine Line Etching Revisited (Part B)

Karl H. Dietz (for CircuiTree Magazine, January, 2009)

Karl Dietz is the development manager at DuPont's Electronic Materials Laboratory, Research Triangle Park, NC. His responsibilities include application studies for printed circuit materials. Karl has 35 years of experience in a variety of R&D, manufacturing and quality control functions and holds a PhD. in organic chemistry from the University of Frankfurt, Germany. If you would like to participate in the exchange or if you have any questions, Karl Dietz can be reached at 919-248-5248, fax: (919) 248-5132, or via e-mail <Karl.h.dietz@usa.dupont.com>.

Previous Tech Talk articles (Ref. 1, 2) looked at the limitation of forming fine line circuits due to undesirable lateral etching (undercut), not just in the print & etch process, but also in pattern plating, panel plate/ tent & etch, and even in SAP (semi-additive processing). It appears that neither photoresist resolution, nor plating capabilities, but rather etching presents the ultimate limit for these traditional circuitizing techniques. This column, the second of a two part series, looks at ways to extend the subtractive technology to achieve finer features. Some technical advances described here have found commercial acceptance whereas others don't appear to have gained traction.

There are several problem areas associated with etching, some interrelated, some independent (see Figure 1). Benefit from process remedies may be seen in one or more of these problem areas. The first problem area shown in Figure 1 was addressed in Part A (Ref. 3), and the latter three are dealt with here

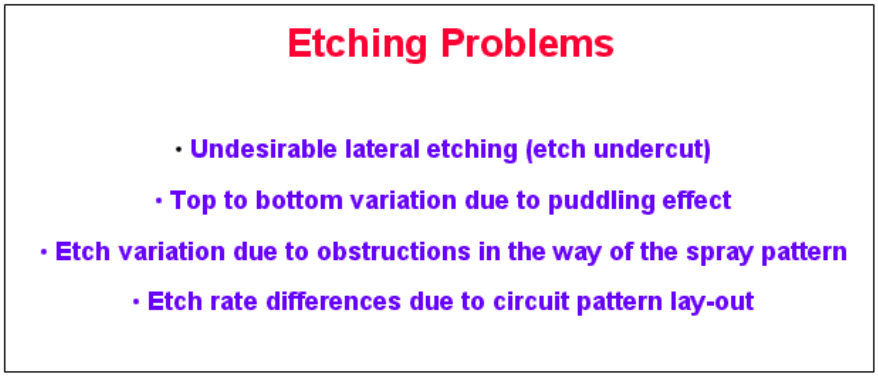

Figure 1: Problem Areas in Etching

Most of the top-to-bottom etch variation (see Figure 2) stems from the so called puddling effect which causes a slower etch rate near the center of the top side of the panel due liquid build-up which is not the case on the bottom side because of the faster liquid run-off facilitated by gravity.

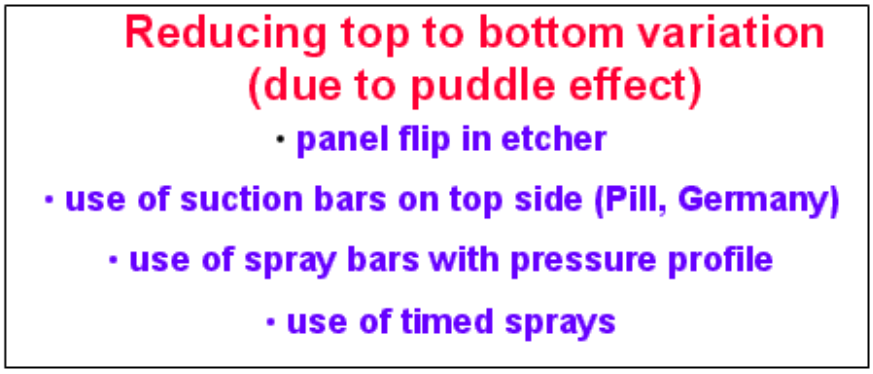

Figure 2: Measures to Reduce the Puddle Effect

The practice of flipping the panel half-way through the etcher doesn't actually eliminate the puddle effect but cuts it in half by spreading it over both surfaces.

The use of suction bars, alternating with spray bars on the top side of the etcher (Ref. 4) as a means of removing the puddle by mimicking gravity on the panel top side has improved etch uniformity significantly (see Figures 3 and 4).

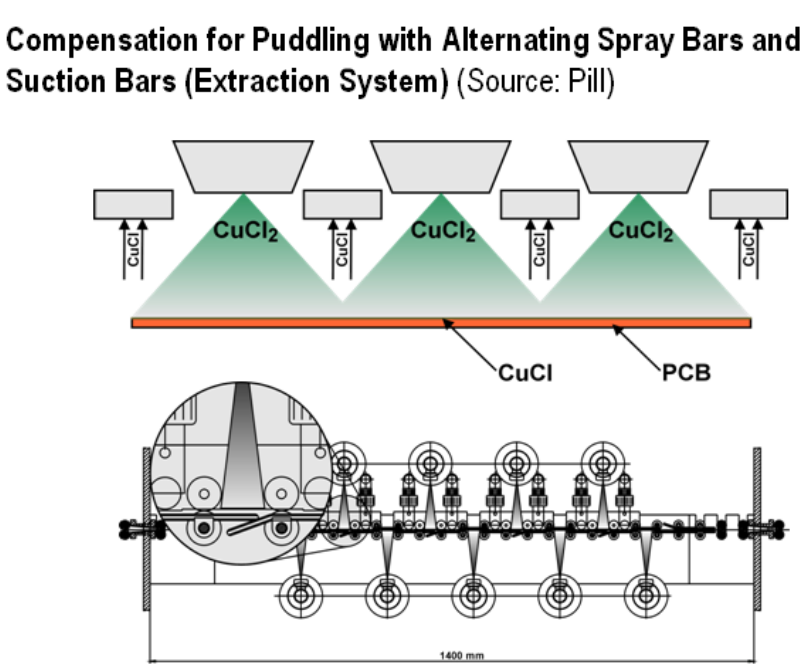

Figure 3: Illustration of an Etchant Extraction System (Source: Pill)

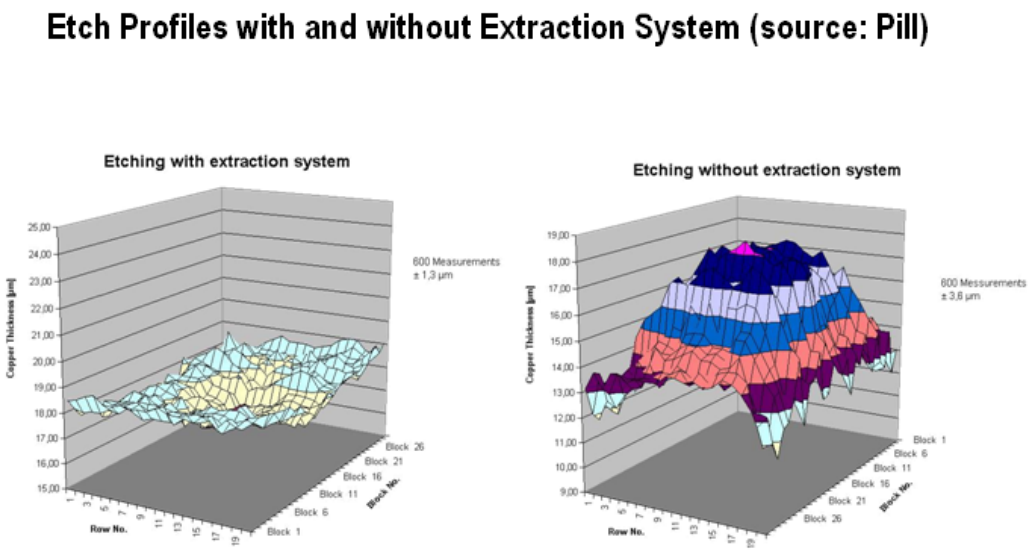

Figure 4: Effect of Extraction System on Etch Uniformity

Another technique that is being practiced to reduce the puddle effect is the use of a spray pressure profile whereby the etchant stream enters the spray bar at the center, which is where the center of the board travels. The spray pressure is highest at the center, tapering off at both ends of the spray bar. Similar results are achieved by timing the sprays on/off, synchronized with the board movement, to deliver more spraying action to the center of the board.

Figure 5 summarizes ways to minimize uneven shadowing of the board surface due to obstructions to the spray which can lead to uneven etching. Modern conveyorized etchers apply these techniques.

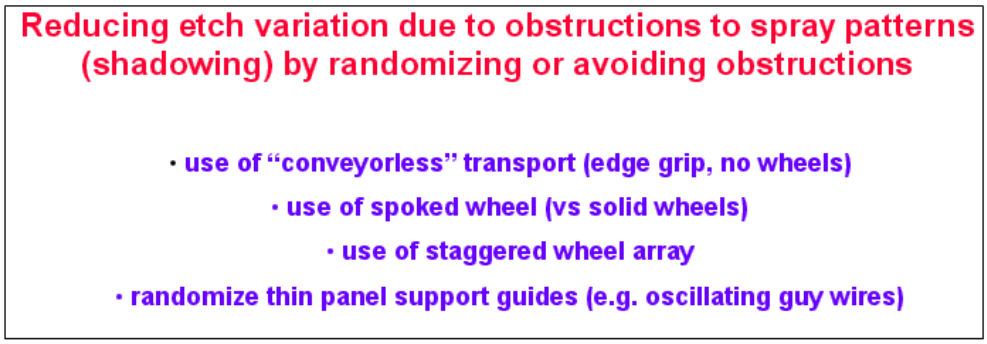

Figure 5: Reducing Etch Variation due to Shadowing

Since conveyor wheels obstruct sprays, so called "conveyorless" transport systems have become popular. They are not really conveyorless, but most, or all wheels have been either replaced by traveling ledges supporting rigid boards on both edges, or edge grips for thinner panels that hold the panel under slight tension. If conveyor wheels are being used, they are spoked wheels as opposed to solid wheel to minimize the obstruction, and the wheels are staggered to randomize the obstruction. If the etcher features support guides for thin panel transport, these guides are also randomized, for example. by oscillating guy wires.

The circuit design pattern also introduces etch rate variability as copper etches slower in narrow etch channels versus wide open copper areas (Figure 6)

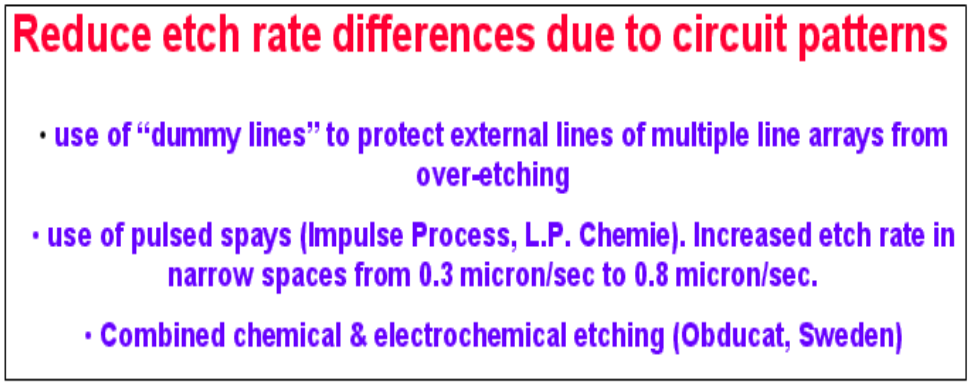

Figure 6: Minimizing Etch Rate Differences due to Circuit Patterns

If several circuit lines run parallel and are separated by equal width, narrow spaces, the outside lines will etch faster than inside lines and will therefore become narrower which is undesirable. One approach to avoid this, assuming the design allows enough room for it, is to flank the outside, functional lines with non-functional ("dummy") lines (see Figure 7). Now the non-functional lines will over-etch which is of no concern. The same concept can be applied to the Siemens and Atotech panel plate/ "tent & etch" processes mentioned in Part A. These processes make use of laser ablation of an immersion tin or organic etch resist. Instead of laser ablating all non-wanted copper, which consumes a lot of time, one can separate a circuit line from non-functional, large copper areas by ablating only a small gap, forming a space of equal width to the other spaces separating circuits.

The use of pulsed sprays (Impulse Process, LP-Chemie) was mentioned in Part A. Since the pulsed sprays increase the etch rate in narrow spaces, this technique will reduce etch rate differences due to circuit patterns.

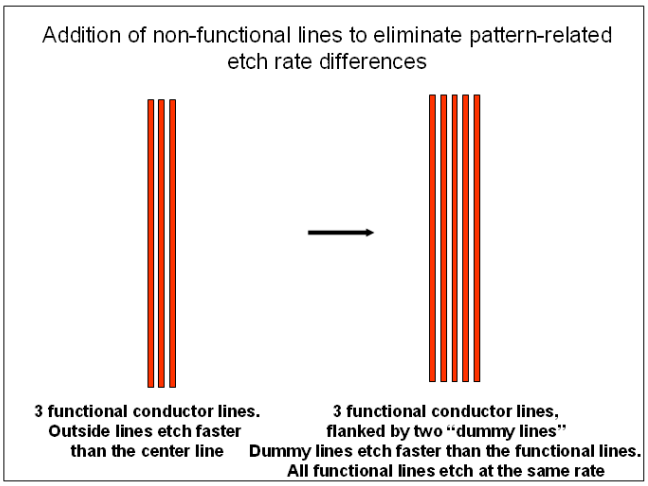

Figure 7: Addition of Non-functional Lines

Another interesting approach is the combination of chemical etching and electrochemical etching (or de-plating) as described in Reference 5 (see Figure 8). The board, covered with a resist pattern, becomes the anode in a plating cell that also contains an etchant. Chemical etching is slow in narrow openings in the resist, and it is faster in wide open areas. With electrochemical etching, on the other hand, the etch speeds are reversed: small openings in the resist, i.e. small copper features surrounded by large resist areas, are areas of high current density as indicated in Figure 8 by the higher density of field lines. Here, copper de-plates (corrodes) faster than in wide open areas of lower current density. So the differences in chemical and electrochemical etch rates offset each other, resulting in more uniform etching.

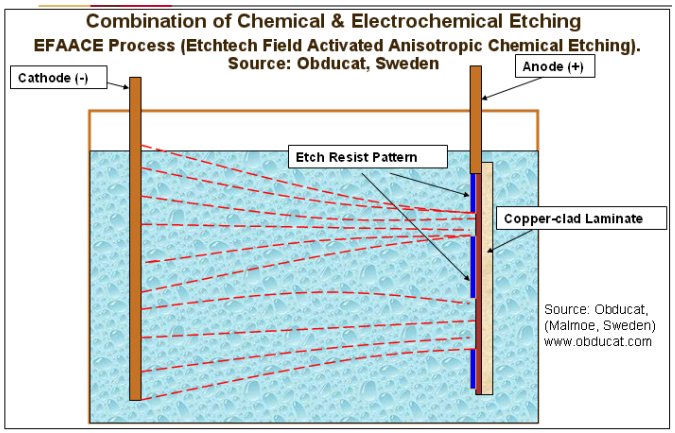

Figure 8: Combination of Chemical and Electrochemical Etching

References

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3. Fine Lines in High Yields, (Part CLIX) : Fine Lines – Fine Line Etching Revisited –Part A, Karl H. Dietz, CircuiTree Magazine, November 2008
4. Vakuum-Aetz-Technologie, Volker Feyerabend, PLUS (Produktion von Leiterplatten und Systemen) 8/ 2007, pg. 1444
5. A New Etch Technology for New Demands, Per Petersson et al, CircuiTree Magazine, September 2001, pg. 53 (also: "The Impact of EFFACE on the production of PCBs", B. Junno and P. Petersson, Proceedings EPC 2000)