Tech Talk

Fine Lines in High Yield (Part CLIX)

Fine Line Etching Revisited

Karl H. Dietz (for CircuiTree Magazine, December, 2008)

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 etching presents the ultimate limit for these traditional circuitizing techniques. This article 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 is addressed here in Part A, and the latter three are dealt with in Part B.

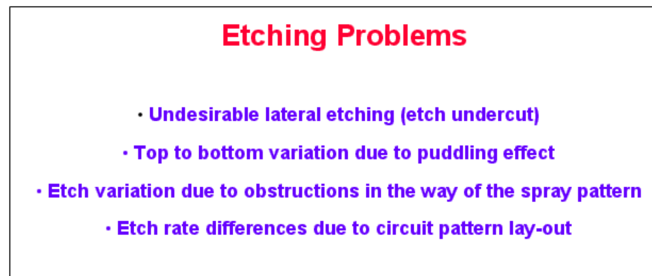

Figure 1: Problem Areas in Etching

Addressing etch undercut first (see Figure 2), we have to acknowledge that wet etching is basically isotropic, and all techniques we apply to promote downward etching do not completely eliminate lateral etching

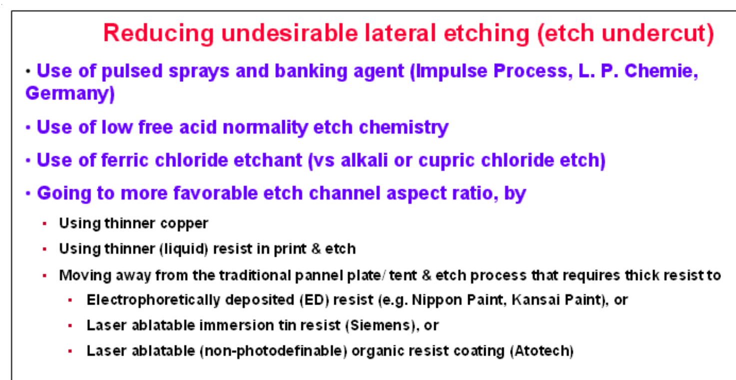

Figure 2: Approaches to Reduce Lateral Etching

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LP-Chemie's Impulse Process (Ref. 3) creates spray pulses of etchant droplets with high vertical impingement force onto the copper surface that easily penetrate an etch inhibitor layer (banking agent) at the bottom of the etch channel but leave the inhibitor layer on the etch channel sidewalls largely undisturbed. This technique results in enhanced downward etching, i.e. a more favorable etch factor, and higher etch speed. The pulses are generated mechanically by the rapid rotation of a coaxial pipe sleeve with slots around the spray bar. This process is combined with Pill's top side suction bar approach that addresses top-to-bottom etch non-uniformity due to puddling (Ref. 4).

It has been reported that controlling acid etchants at very low free acid normality improves the etch factor (Ref. 5). These findings are in line with earlier work that showed that by using NaCl instead of HCl as a source of chloride ions in acid etchers, to complex copper salts and keep them from precipitating, results in an improved etch factor.

Different etch chemistries result in slightly different etch factors. Alkaline etching typically yields a less favorable etch factor than acid etchant. Some studies show a better etch factor with ferric chloride than with cupric chloride, but results are not always conclusive. The study of T. Yamamoto et al (Ref. 6, see also Figure 3) shows the beneficial effect of wider etch channels and thinner resist, but gives no clear distinction between ferric and cupric chloride.

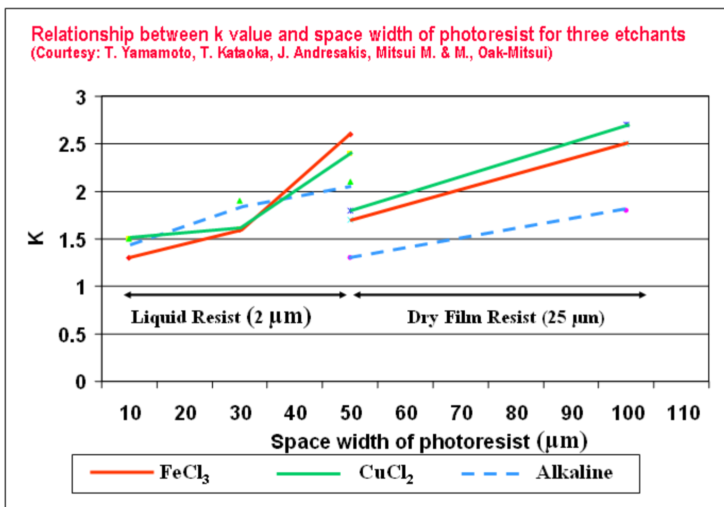

Figure 3: Relationship between Etch Factor, Etch Channel Width, and Resist Thickness for Three Etchants (source: Oak Mitsui)

The study of Reference 6 has shown that the etch factor deteriorates as the etch channel aspect ratio increases and as the absolute dimension of the etch channel width shrinks. This suggests, that wherever design and image transfer method allow a change to thinner copper and/or thinner resist, one should move in that direction to improve selective downward etching. A special application of this approach can be found in panel plate/ tent & etch. In the classic tent & etch process, a relatively thick dry film resist is used to protect with a tent the throughhole copper from etchant attack. This thick resist adds height to the aspect ratio of the etch channels which is known to result in a less desirable etch factor, thus limiting fine line etching. The use of a much thinner etch resist that coats the plated throughhole instead of protecting it with a thick tent will improve the etch factor. For example, a positive ED resist coating, is much thinner than the tenting film, enabling finer lines on a panel plated board. Positive resist is preferred over negative working resist in this application because no radiation needs to reach the ED resist in the hole during exposure to form a coating resistant to the developer chemistry. Alternatively, the thin coating could be immersion tin, as in the Siemens process. The tin is selectively laser ablated from the copper surface where copper will be etched. Similarly, a process, developed by Atotech, uses a laser ablatable non-photodefinable organic coating for this application.

References

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