# Tech Talk

## Fine Lines in High Yield (Part CXLII)

## Improving and Measuring Tenting Performance of Dry Film Photoresists

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A few years back I covered dry film tenting in three Tech Talk articles (Ref. 1-3). The tenting process as an alternative to pattern plating had been championed by IBM board circuit board facilities and alumni of these sites that spread the technology to other sites. With the demise of the IBM shops, the tenting process has lost visibility in the US and Europe but it is alive and well in Japan. The tenting process has also been employed in applications other than the classic alternative to pattern plating. To avoid "double drilling", the pattern plate resist can be used to tent tooling holes of the board that is being pattern plated. After pattern plating, metal resist plating, resist stripping, the thin electroless copper is etched out of the tooling holeas the board surface is etched. The tooling hole then has the correct hole diameter chosen for the tooling pins. In another application, the resist tents pads only after solder plating so that the exposed solder on copper traces can be selectively stripped, leaving solder on the pads and in the plated through-hole.

This Tech Talk column will cover a few aspects of the tenting process that were not covered in detail in References 1-3.

### Measuring Tenting Strength of Dry Film Photoresists

**Stressed Tenting Tests**

Tenting resists have to perform almost perfectly because a board may have thousands of hole, and one broken tent will cause a scrapped board. Therefore tenting tests are often done under stressed conditions to obtain a statistically significant number of tent failures. One way to stress the tenting performance is to subject the tented board to multiple passes through the developer or through the etcher, or through both process steps. Another method uses a test board that features extra large holes to take advantage of the fact that large holes typically show a higher tent failure rate than small holes.

**Stress-Strain Test**

Reference 4 describes a stress strain test that yield useful information on the tenting performance of a dry film resist. The method involves a biaxial stress-stain Instron® test whereby a probe stretches and punctures the film that is laminated over a hole in a copper-clad board. From stress-strain data, information on initial (Young's) modulus, average percent elongation and biaxial strain, strength at break, and work of rupture can be obtained. When plotting "Strength at Break" or "Work of Rupture" vs exposure energy, one can see that strength at break increases greatly from unexposed resist to resist exposed at low exposure energy, then reaches a maximum at some exposure energy, and drops again at even higher exposure doses. The drop is attributed to resist embrittlement when over-exposed. The test thus gives the optimum exposure energy for best tenting strength. This exposure energy is not necessarily the optimum exposure dose for best resolution or other performance parameters. The test can also be modified to get some indication of the influence of processing chemicals such as developer or etching chemistry on tenting strength. In the study of Reference 4 the effect of developer chemistry on tenting strength was tested. Since the test film was a solvent-processable resist, the developer chemistry was 1,1,1-trichloroethane. The developer weakened the tents at very low exposure but actually increased strength at break at higher doses, a behavior that aqueous processable films most likely won't show.

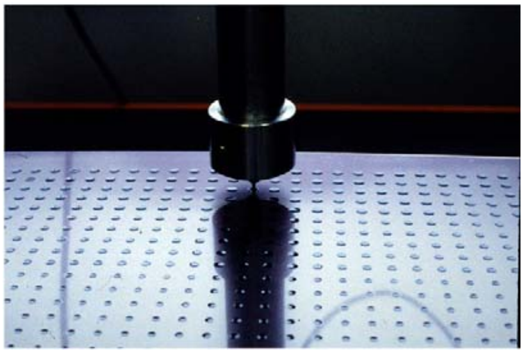

*Fig. 1: Instron® Probe Testing Tent Strength*

## Optimizing the Tenting Process

**Exposure**

The above mentioned stress-strain test is a good way to zero in on the right exposure conditions. It is interesting to note that the preferred exposure dose for tenting may be 10-20% higher than what is needed for non-tenting applications. This has to do with the role of oxygen as an inhibitor in radical polymerization. Residual oxygen in the resist scavenges photo-induced radicals first until the oxygen is consumed and additional radicals then start the polymerization. The polyester coversheet acts as an oxygen diffusion barrier during exposure to avoid more radical consumption in this undesired side-reaction. In the tenting process the photoresist is still exposed to the oxygen trapped in the hole which consumes more radical as it diffuses into the resist so that a higher exposure dose is needed to overcome this effect.

**Development**

Full cone nozzles, as opposed to fan nozzles, have been recommended to reduce the impingement impact of the sprays on the tents. Good maintenance of the spray nozzles is also needed to avoid partially plugged nozzles that cause higher spray impact on the tent. Occasionally "wrinkled" tents are observed, signaling a potential problem. Lowering the developer drying temperature e.g. from 50ºC to 40-45ºC can avoid this situation.

**Land Designs**

A larger land or pad area is desirable for increased anchoring surface for the tent. Figure 2 shows a land design on the left hand side that offers a larger anchoring surface than the annular ring shown on the right without taking space away from lines and spaces between pads. So called "tear-drop" shaped lands also achieve this purpose.

## Lamination Pre-heating and Post-lamination Cooling

In many process lines one can find a lamination pre-heat station to improve resist conformation and adhesion during lamination. Such pre-heating is typically not recommended in the tent and etch process. If resist conformation and adhesion needs to be improved in tenting it is better to adjust other parameters such lamination pressure or lamination speed. If boards are heated before lamination, the resist tents over a hole filled with hot air. This air will contract after lamination, pull the resist partially into the hole and cause thinning of the tent at the hole edge ("cookie cutter effect") resulting in a weaker tent. To avoid resist thinning at the hole rim even when pre-heat is omitted, many lamination lines for tented boards feature a post-lamination cooling unit that serves the purpose of quickly cooling the resist to make it more viscous before it has time to flow.

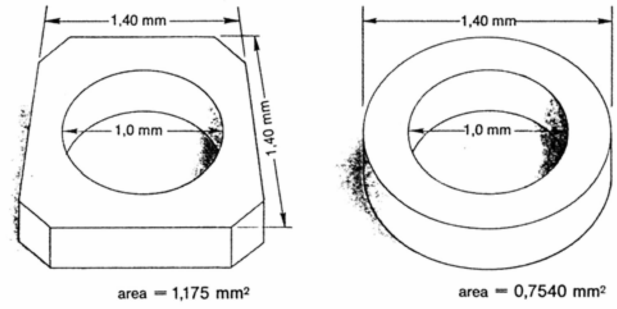


*Figure 2: Land Design for Tenting (left) vs Standard Annular Ring (right)*

References


1 Fine Lines in High Yields, (Part XXXVIII): Tent & Etch (Part 1), Karl H. Dietz, CircuiTree Magazine, Oct. 1998, pg. 108

2 Fine Lines in High Yields, (Part XXXIX): Tent & Etch (Part 2), Karl H. Dietz, CircuiTree Magazine, Nov. 1998, pg. 90

3 Fine Lines in High Yields, (Part XL): Tent & Etch (Part 3), Karl H. Dietz, CircuiTree Magazine, February 1999, pg. 164

4 Physical Properties of Photopolymers – A Biaxial Stress-strain Test, Catherine T. Chang, Photographic Science and Engineering, Vol. 23, Number 5, September/October 1979, pg. 311