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CORPORATION

Technical Information

Note: This paper is the result of a customer support effort that led to an increase in fine line production performance from 75% to 99% over a two week period of Chemcut technical support.

Thoughts on Increasing Yields for Fine Lines and Spaces

Introduction

The market for circuit boards today demands high volumes and low prices even for high tech boards. To make any profit at all a circuit board manufacturer must keep his yields after etching above 95% even when doing lines and spaces of less than 100 microns. This 95% yield is the absolute minimum to make any money, yields in the range of 98 to 99% are even better if the manufacturer wants to make a consistent profit and get repeat business. However, as line and space requirements drop below the 100 µm mark it becomes extremely difficult to keep yields at these high levels. Yields can be improved with newer equipment and facilities as well as changing to newer resists but the data from tests we have done recently at Chemcut indicate that the biggest gain in yields (or biggest loss in yield) are made at the exposure step.

Clean Rooms and Collimated Light Exposure Units

The first thoughts that come to mind when talking about fine line yields are usually directed towards clean rooms and collimated light exposure units. A clean room will reduce the number and size of particles that could cause opens in negative acting etch resists or shorts in positive acting etch resists while a collimated light exposure unit will cut down on light scattering that might undercut a narrow trace leading to an open or span a narrow space causing a short. While both these measures will lead to an increase in yields it might not be by as much as most people think.

In the summer of 1999 we were finally able to afford to install a class 10,000 clean room with an up-to-date collimated light exposure unit. Prior to this we had an isolated yellow room that was air conditioned and kept at positive pressure in relation to the rest of the building but no filters or anti-static units and no procedures for minimizing particle contamination. We were also using an older, non-collimated light exposure unit. We were able to operate under these conditions since our lab was not a production facility but was in place to test and demonstrate wet processing equipment. Absolute yields were not of the highest priority to us since most equipment related causes of yield loss are relatively easy to diagnose and have long since been designed out of the equipment. Most cases of poor yields were found to be caused by processes other than developing and etching.

Before the installation of the clean room and new exposure unit we ran a test to determine our yields for 75µm (3 mil) lines and spaces and repeated the tests, using the same exposure procedures, after the installation of the clean room and collimated light exposure unit. For each test, ten 460 mm x 610 mm (18”x24”) panels with 35µm foil were imaged with fine line test patterns on both sides and etched. The fine line test pattern used was one from Conductor Analysis Technologies and consisted of a combination of 75, 100, 125, and 150 µm (3, 4, 5, and 6 mil) lines with 75, 100, and 125 µm spaces between them. Each test pattern is about 2.5 cm (1 in.) square and there were 352 patterns on each side of the panel in a 16 x 22 grid for a grand total of 7004 test patterns on both sides of ten panels. The length of the 75 µm line in each test pattern was about 66 cm (26 in.) as was the length of the 75 µm space. The total length for each of the 75 µm lines and spaces in all ten panels was approximately 462,544 cm (182,104 in.) for a combined length of 925,088 cm (364,208 in.). After etching the panels were sent to Conductor Analysis

Technologies, where they have special equipment for quickly measuring yields as well as line width uniformities, for analysis.

The results showed that the total feature yield for the 75 µm lines and spaces was 94.6% (i.e. 94.6% of the 7004 test patterns showed no shorts spanning the 75 µm spaces or opens in the 75 µm lines) with the old exposure room and non-collimated exposure unit and 98.2% with the class 10,000 clean room and new collimated light exposure unit. This is a substantial gain but the real surprise was that we were getting almost 95% yield before the improvements while many production facilities were struggling to get 70% yields for fine lines and spaces even with clean rooms and the best exposure units. Why were we able to get much better yields without the benefit of a clean room and collimated light exposure unit?

Hold Time Before Exposure

Some of the difference no doubt is due to the difference in atmosphere between a test laboratory and a production facility but we found in the mid-1980's when we first stated testing with 75 µm lines and spaces that good contact between the photo-tool and the Mylar protective sheet covering most dry films was critical in resolving tight lines and spaces. In order to get good contact we found that holding the panel for a specified length of time after the vacuum had been drawn on the exposure tray before doing the actual exposure was the key. Up until we installed the clean room and new exposure unit our procedure for exposure was to draw down the vacuum on the exposure tray until the pressure gage reached its set point then hold the tray for one minute before pushing it into the exposure unit and exposing the dry film. After installing the clean room with the new exposure unit we found we could reduce the hold time to 30 seconds but that the hold time was still critical to getting good yields.

In the summer of 2001, in the process of installing some new equipment at a customer site we took the opportunity to confirm this. The customer has a class 10,000 clean room with collimated light exposure units. Most of their work is high volume, low tech panels, such as back planes, but they are capable of doing fine lines also and a small percentage of their product are high tech boards. Their procedures for exposing the high tech boards are different than those for their low tech product, the major difference being a hold time of 30 seconds before exposure for the high tech panels. Normally the panels are exposed as soon as the vacuum gage reaches the set point.

Using the same test pattern as above, one group of ten test panels was exposed using the standard procedure with no hold time before exposure and another group of ten exposed using the fine line procedure with a 30 second hold time before exposure. Both groups were etched and sent to Conductor Analysis Technologies for analysis. The results showed that the total feature yield for the 75 µm lines and spaces for the group without the hold time was 76.5% while the yield for the group with the 30 second hold time before exposure was 99.4%. Most of the loss in yield was due to shorts across the 75 µm spaces because of off contact between the photo-tool and dry film.

Conclusions

There is no doubt that a hold time between vacuum draw down on the exposure tray and actual exposure will increase the yields on fine lines and spaces by a very large amount. The disadvantage, of course, is a loss of productivity but the difference between a 75% yield and a 99% yield will fairly quickly pay for more equipment to bring the productivity back to its former level in a high volume production situation.