PCB TECHNOLOGY

Vacuum etching technology

The so-called puddle effect can be avoided using the vacuum etching technology developed by Pill, by means of which more even etching results are achieved. An intelligent plant design enables both finely tuneable control and service-friendliness.

In search of ultra-fine structures

With their vacuum-etching technology, the Auenwald-based *Pill GmbH* have been one of the most important developers of technology for horizontal lines in the PCB industry for many years (*PLUS 6/07*, p.1099). In developing technology for the manufacture of conductors, prevention of the so-called puddle effect is just as important as the improvement of the conductor flanks in the ultra-fine structure range.

An ingenious solution to many problems

The greatest problem in manufacturing PCBs is the even application of the etchant. The market's demands for ever finer structures have grown constantly over the last few years, making technological improvement in the PCB production process indispensable.

In the etching process, one of the fundamental procedures in the manufacture of PCBs, the usually copper-laminated substrate material is coated with an etchant-proof resist, which is subsequently structured by photographic means. The desired PCB pattern is created by etching away the unprotected copper. In practice, however, several physical problems arise during this course of this process.

As a rule, horizontal lines are used. A flaw can often be determined here: different etching results on the upper and lower sides of the board can often be observed. Precise examination of the upper side of the board reveals large differences between the edge of the board and the centre with regard to the etching rate, whereby etching proceeds faster at the edge of the board than in the centre. Accordingly, the conductors at the edge of the board exhibit a greater degree of undercutting than the conductors in the centre of the board. Attempts to balance the layout by widening the conductors at the edges produced unsatisfactory results in the ultra-fine conductor range and this method was therefore abandoned.

The phenomenon of undercutting of conductors at the edge is relatively simple to explain: the etchant exchange works better at the edge of the upper side of the PCB because the etching medium used can drain off more easily here. Due to various technical hindrances, the so-called puddle effect (or lakes of etchant) occurs in the centre of the board. The transport rollers in particular prevent the etchant from draining off evenly and it accumulates between the rows of rollers. This has consequences in particular for the production of large boards and the manufacture of ultra-fine structures. Technical limitations and production yield hence restrict the range of products and the profitability of PCB production.

Various development approaches have attempted to tackle this problem. Engineering measures, such as individually adjustable spray bars parallel to the direction of transport, oscillating spray manifolds or corrective re-etching systems brought improvements, but only with a huge amount of technical effort, which was then reflected in the prices of the plant systems and production.

But why make such elaborate corrections? *Pill GmbH* chose a different route and approached the problem at its roots with their vacuum etching technology.

Innovation: vacuum etching technology

Pill GmbH brought a practicable and more economic solution to the problem of etchant distribution onto the market a few years ago (*fig. 1*). With the successful development of the vacuum etching technology, an even extraction of the etchant is achieved, which leads to outstanding results on the circuit board. Even during the first examinations and test series it was established that both the trend on the upper side of the board and the comparison between the upper and lower sides showed more even etching rates.

address:
Pill GmbH
Postfach 11 64
Industriestraße 7
D-71547 Auenwald

communication:
Telefon: 0 71 91/35 52-0
Telefax: 0 71 91/35 52-35
E-Mail: info@pill-germany.com
Internet: www.pill-germany.com

Managing Director / HRB:
Ust.-IdNr./VAT-IdNo.: DE 812578211
HRB 271469, Stuttgart
Dietmar Seifert

Fig. 1: Example of a vacuum-etching plant

The idea is as simple as it is impressive: suction units installed between the spray bars at a small distance to the circuit board surface extract the used etchant and feed it back in a closed circuit to the module tank (*fig. 2*).

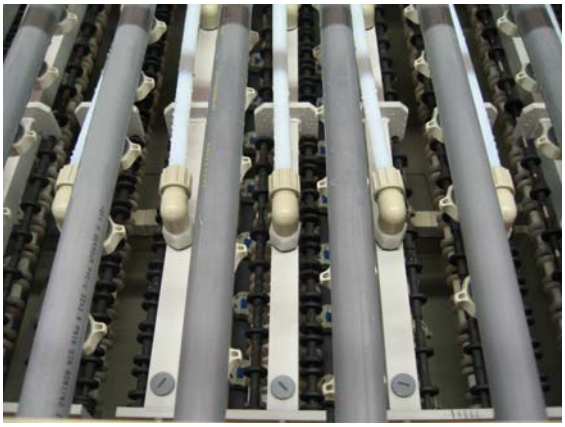
Fig. 2: The suction tubes are arranged parallel to the transverse spray bars

An adjustable negative pressure is generated in these suction units, hence preventing the formation of lakes and puddles between the transport rollers. In order to guarantee the optimum distance between the suction rails and the circuit board at all times, the extraction units are coupled to the upper fixing rollers of the transport system.
The result and customer experiences are impressive: an optimum extraction rate can be achieved for all types of circuit board, which naturally leads to the best results. On the upper side of the board, layer thickness fluctuations of a mere ± 1 µm have been determined over the entire effective surface (650 mm x 650 mm). Differences between the upper and lower sides of the board are hardly detectable any longer.
The PCB manufacturer's production yield, range of products and productivity are hence directly and positively influenced.

Steeper etched sidewalls

Joint examinations with leading PCB manufacturers have shown above all that steeper etched sidewalls can be achieved using this new technology. This means that the ever more demanding layout specifications can be adhered to, even in the ultra-fine structure range.
One of the fundamental factors here is the etching factor, a value that reflects the steepness of the conductor sidewalls. As is well-known, an etching factor of 1 is achieved by mere dip-etching, which increases to 2 to 3 by means of streaming measures, e.g. spray etching. Due to the innovative vacuum etching technology, however, this value moves significantly towards 4. Excellent values are also achieved for the shrinkage factor, which describes the lateral attack of the etching medium under the resist.
As good as these results and findings are, only around 50 % of the etching result can be influenced in this way. Additional factors also play an important part: the thickness of the resist, the quality of the exposure and development process, and finally of course the thickness of the copper lamination being etched.

Increasing productivity

A further advantage of the vacuum etching technology is the improvement in the exploitation of capacities and production yields, because the higher etching speed leads to a significant increase in the productivity of the etching process, and a high throughput rate can hence be maintained. The intensive constant quality controls associated with this topic and the re-etching that is otherwise often necessary as a separate pass can also be eliminated.
This results in considerable simplification of the plant. In the ultra-fine conductor range in particular, this new technology means that various control engineering additions that were previously necessary can be dispensed with. Oscillating spray manifolds are no longer necessary; intermittent spray nozzle configurations with differently adjusted spray pressures can also be dispensed with by the use of vacuum technology. Above all, it was possible to simplify the construction of the plant modules by using vacuum technology. Since extraction and etching take place

address:
Pill GmbH
Postfach 11 64
Industriestraße 7
D-71547 Auenwald

communication:
Telefon: 0 71 91/35 52-0
Telefax: 0 71 91/35 52-35
E-Mail: info@pill-germany.com
Internet: www.pill-germany.com

Managing Director / HRB:
Ust.-IdNr./VAT-IdNo.: DE 812578211
HRB 271469, Stuttgart
Dietmar Seifert

simultaneously in the same chamber, the spray manifolds can now be installed transversely. On one hand, this simplifies handling, because these spray bars can be exchanged quickly and easily due to the bayonet fastening (fig. 3).

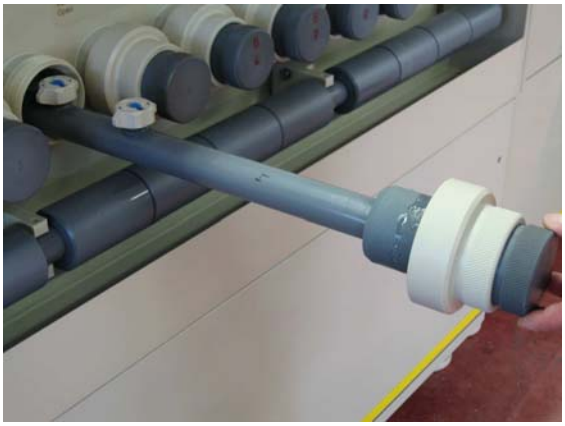

Fig. 3: The transversely installed spray bars can be removed quickly and easily for maintenance work

Due to its construction, this arrangement requires much less maintenance, since oscillation is also no longer needed. The longitudinally designed spray manifolds, whose spray pressures needed to be individually controlled, are hence also redundant. This was necessary in the past in order to achieve even distribution of the etching medium on the board. The advantages of this new technology are hence obvious: no puddle formation, even distribution of the etching medium, simplified operation and, above all, a practical modular construction and increased profitability.

Electronic monitoring of the flow volume

Due to the installation of the spray bars at right angles to the running direction, electronic monitoring of the flow volume can now be implemented simply for each individual spray bar. The user is able to see immediately which spray bar is responsible in the event of irregularities. He can then react quickly and purposefully. If a nozzle does block up during daily use, this problem can be rectified within a few seconds. Since all of the spray bars are provided with a bayonet fastener, no elaborate and hence time-consuming conversion measures are necessary.

The future of vacuum etching technology

Vacuum etching technology offers enormous potential for the future of printed circuit board manufacturing. It will become all the more important, since fine and ultra-fine conductor structures are placing and will continue to place ever greater demands on etching technology. Experiments with conducting pattern structures of less than 50 µm have yielded impressive results. There are currently still a barely comprehensible number of possibilities here for both the national and foreign markets.

A development team at Pill GmbH is working continuously on the further development of the technology and, for example, is attempting to find out how far the limits of the technology can be pushed for thick copper circuits, various chemicals and the materials used. “The main objective of our development is to be able to constantly and cleanly control PCB manufacturing by means of vacuum etching technology with various chemicals and thereby to achieve evenness for all copper layer thicknesses and top quality for our customers,” says the responsible Development Manager, *Dietmar Seifert*.

Ferric (III) chloride as a trend?

As a further etchant in the photographic structuring process, ferric (III) chloride represents a promising extension to the spectrum. Experiments with this etching medium are hence a very interesting approach by *Pill*. Examinations and individualised customer projects are currently being pushed further by the development team. This material is once again being used more often and is in greater demand, particularly in Asia. First research approaches and experiments have been executed, and work is proceeding intensively to perfect the system with regard to a broader market introduction.

Cost advantages

The two main advantages of vacuum-etching technology – correction-free etching and in particular the resulting compact design - have a positive effect on the entire system. To date, the only alternatives to this technology are elaborate process steps or corrective procedures, which draw the short straw when it comes to profitability. Demand for the vacuum-etching technology is growing and the technology has now established itself in

address:
Pill GmbH
Postfach 11 64
Industriestraße 7
D-71547 Auenwald

communication:
Telefon: 0 71 91/35 52-0
Telefax: 0 71 91/35 52-35
E-Mail: info@pill-germany.com
Internet: www.pill-germany.com

Managing Director / HRB:
Ust.-IdNr./VAT-IdNo.: DE 812578211
HRB 271469, Stuttgart
Dietmar Seifert

particular in the Asian market. It is considered to be an optimum solution for clean, precise etching, even for large scale throughput. Above all, the practical modular construction with individually removable and of course replaceable spray bars is well suited for industrial production.

Contact addresses

Dietmar Seifert, Pill GmbH, Industriestraße 7, 71549 Auenwald, Tel. +49 (0) 7191/3552-0, Fax -35, info@pill-germany.com, www.pill-germany.com;

Dipl.-Ing., Dipl.-Betriebswirt Volker Feyerabend, APROS Int. Consulting + Company Services, Brühlstraße 32, 72800 Eningen u. d. Achalm, Tel. +49 (0) 7121/98099-11, Fax -19, www.APROS-Consulting.com, www.APROS-Services