#32014

INFOCUS:

High-tech PCBs

– Make the right choice from design to volume production

A topic from NCAB GROUP about integrated PCB production

A horizontal plating line used for copper filling of micro vias on HDI product.

Modern electronic products are expected to offer more and more advanced functions, while the products themselves are becoming smaller and smaller. This puts greater demands on the PCB design and also the aspects relating to the PCB manufacturing process. There are two key factors for the successful production of high quality advanced PCBs; firstly, making the right choices at the design stage – and then carefully choosing the factory that can support the specific technical demands of the project in question.

We are seeing an increasing number of electronic functions being squeezed into smaller and smaller products. Whether it's consumer electronics, computers, automotive or medical technology, the overall trend is reduction in size. Not just through a reduction in actual or finished product size, but also as the components themselves are becoming smaller, so the assemblies have to be more densely packed and using smaller features.

Chris Nuttall, Chief Operating Officer at NCAB Group takes up mobile phones as an example:

"Just consider the way they have evolved. A modern phone is not just a phone, it's a smartphone – it's so much thinner, lighter and smaller than the mobiles we had 20 years ago, but in terms of what it can do, it is light years more advanced than its predecessors. As a consequence, the PCBs inside are having to accommodate more and more functions making the design itself much more complex, and all of this on smaller and smaller circuit boards. Let's take an example of a product fitted with NCAB's PCBs, a Hasselblad camera. Take the Hasselblad H1D, which was released in 2002, and could deliver images with resolutions of up to 22 megapixels. The images produced by Hasselblad's latest model, the H5D, can have resolutions of up to 200 megapixels. The sensors, memory and processors at the core of this new and vastly more advanced technology obviously demands a much more complex PCB at its heart.

Chris Nuttall, Chief Operations Officer, NCAB Group.

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CHRIS NUTTALL, NCAB GROUP

The onset of these increasingly sophisticated electronic products, has led to more advanced PCBs becoming more commonplace.

The specifications here require so-called HDIs, or High Density Interconnect solutions with greater number of layers, more connections both on the surface and inside the PCB, utilising finer conductor widths and narrower spaces between them, all leading to the design that is based upon smaller, laser-drilled microvias (blind vias), since normal through hole vias simply wouldn't fit into the space available. Therefore we are seeing manufacturers producing more boards that also incorporate buried vias. All of which increases the number of interconnections within the board and frees up valuable space on the outer layer for more components to be placed.

The increased number of layers, together with the micro via technology also requires the use of thinner prepegs and cores than in conventionally manufactured boards which also leads to increased demands upon the factories.

MORE PRODUCTION STAGES

"Widespread miniaturisation is putting far greater demands on the production equipment at the PCB factories. Many of the stages in the production of HDI boards *are* similar to those used for the manufacture of conventional boards. However, HDI production calls for considerably more sophisticated equipment in order to achieve the tiny geometries that are required." Says Kenneth Jonsson, Technical Manager at NCAB Group Sweden.

"And not only does incorporating several layers of buried vias and/or micro vias into the boards require a number of additional steps, but these also need to be repeated several times and all of that increases the degree of complexity and the risk of error." He says. "All the geometries are much smaller on HDI boards, which calls for better dedicated equipment designed for high-tech manufacturing. Many factories do have laser drills, but there aren't, unfortunately, as many who also possess the appropriate plating equipment and processing experience to enable them to actually make good-quality, reliable HDI boards. That's why NCAB puts a great deal of time and effort into qualifying and verifying a factory before giving it our seal of approval to manufacture HDI boards for our customers.

"The first consideration in generating micro vias is that of advanced laser drills that can drill blind holes, down to 50µm, although most micro vias normally have a diameter of around 100µm. The latest generations of these machines are capable of drilling up to 500 holes a second." Says Kenneth Jonsson.

Following on from that, the transferring of the circuit pattern onto an HDI board is an equally critical operation that calls for the highest precision, which the traditional photography based techniques can't achieve. Instead, HDI board makers either use CCD camera aligned imaging machines with parallel lighting, or Laser Direct Imaging (LDI) systems, which images the pattern directly onto the bonded photo-imagable material. This makes for improved quality as no photo tool film is used thus enabling a much greater accuracy of transfer of pattern features down to 50µm.

A Laser Direct Imaging (LDI) machine transfers and prints the pattern directly onto the circuit board material by means of laser beams.

THE RIGHT EQUIPMENT AND CLEAN ROOMS ARE PREREQUISITES

"To ensure the best possible result in the imaging transfer process, it's vital that it's performed in special clean rooms with carefully controlled temperature and humidity levels." Explains Kenneth Jonsson.

Kenneth Jonsson, Technical Manager, NCAB Group Sweden.

The clean rooms that have been used for these processes meet the US FED STD 209E 10,000 class. This class has constituted the industry standard for many years now and stipulates that the concentration of airborne particles ≥0,5µm (a human hair is typically 20 – 50µm thick) in size should not exceed 10,000 particles per cubic foot.

"Today the best factories have clean rooms that meet the class 1,000 requirements. To give another idea of what this means; the air in our normal everyday environment contains 1 million particles, of the same size, per cubic feet. However, good quality clean rooms are expensive, both to buy and to properly maintain." He states.

"Widespread miniaturisation is also putting far greater demands on the production equipment at the PCB factories and calls for considerably more sophisticated equipment in order to achieve the tiny geometries that are required."

KENNETH JONSSON, NCAB GROUP SWEDEN

Producing HDI boards also requires a different type of plating line. For non-HDI boards one can usually make do with ordinary plating lines, with vertically held panels that use mechanical and air agitation, allowing you to get the plating chemicals to facilitate good copper plating onto the surfaces and into the holes (the through hole part of the plating requires good solution flow within the holes or you will not obtain a reliable or uniform plating thickness). However this method isn't really suitable for HDI boards with blind holes that can measure 100 µm or less in diameter. That's why most factories use both horizontal plating lines as well as Vertical Continuous Plating, VCP lines. These methods involve spraying the plating chemicals onto the pads under high pressure, which ensures that the micro vias are properly plated.

Positioning the solder mask correctly against the pattern poses a significant challenge, since extreme components, for example 01005 and µBGA circuits with 400µ or finer pitches have to provide registration down to 37µm, or in extreme cases, 25µm. To achieve this, CCD exposure units are required.

"PCB makers now have the possibility to use special LDI units to exposure the soldermask, as the soldermask manufacturers have developed special soldermask inks, to support HDI designs, that require lower energy to polymerize." Says Kenneth.

LOOKING 'UNDER THE BONNET'

Chris Nuttall explains that the NCAB Group has to carry out a thorough examination of all aspects of a factory's production processes and equipment when assessing whether or not it meets the

demands for high-tech manufacturing. As he puts it, it's like looking under the bonnet and servicing the car before buying it.

"If a factory says that it has laser drills, and is therefore capable of producing reliable high-tech PCBs, it's rather like saying that all you need to do in order to become a new Michelangelo is to get yourself a hammer and chisel. We know that laser drilling equipment is not the start and finish when it comes to HDI production - it's equally as important to have the right kind of plating equipment, to have the right chemistry as well as knowing how to handle, control and verify the full plating process. We also look at what kind of chemicals and methods they're using, image transfer equipment and procedures and this is in conjunction with understanding the numbers behind the factories real experience in this field and their performance – both of which are crucial factors." He says.

"But we are looking for our factories to specialise in manufacturing advanced boards – it has to be a key part of their core activity." Adds Kenneth Jonsson.

Currently there are 11 different factories, across China and Europe, which are able to manufacture HDI PCBs for NCAB's customers.

"We listen and talk to our customers, we work to understand the detail of their designs and their requirements. We find the right factory for each specific project, depending on its complexity, volumes and any other specific demands. And our strategy to ensure that we

Horizontal desmear and PTH line.

maintain and develop a best in class and secure factory base, continues within this field of technology as we always have more than one approved source that can support NCAB and our customers." Continues Chris Nuttall.

All this certainly rings true according to one of NCAB's customers:

"The highest quality and delivery capability are decisive factors for us. And NCAB Group's flora of carefully selected factories ensures that the capacity is always there and they are able to meet the different delivery times and supply the variety of PCBs we need. Thanks to their efficient quality control measures "on the spot " in China, NCAB's factories always deliver what they promise. NGAB Group is a flexible and secure partner." Says Mikael Borg, Purchasing Manager at Hasselblad.

Kenneth Jonsson emphasizes the importance of the factory being able to not only manufacture advanced PCBs, but also in keeping the number of production errors to a minimum.

"Take HDI boards as an example. Producing this type of board according to the 3-4b-3 method involves laminating, drilling and plating it four times. If they return a 10% rate of failure during each round in the factory, the number of boards they would end up scrapping would exceed the volumes they actually deliver. In such a case you need to question the quality of the items that make it through to the delivery stage." Says Kenneth Jonsson, adding that this should be a cause for concern: "When you consider that the components on the board can cost more than 100 times the board itself, it's imperative you can rely on the quality of the board. Otherwise, it can be incredibly expensive, if you're forced to scrap the product at a later stage."

GET THE DESIGN RIGHT FROM THE START

Yet another aspect you need to prioritise with advanced boards is the design itself. The margins are tiny with regard to such factors as conductor widths, isolation distances between copper features, impedence requirements, hole sizes and their relation to capture and target lands. All this poses a considerable challenge at the layout stage. The design rules should be realistic and adapted to volume production right from the start. Kenneth Jonsson warns of a number of pitfalls when only considering prototype factory design rules: "One example may be making the inner layer cores too thin so as to produce a good capacitive coupling. It might work in a prototype factory, where great care is taken to basically hand-process these thin inner layer cores. However it could lead to major problems when the product is in volume production, since they may have different capabilities and in this instance the thinner cores may easily get stuck during the processing through long, volume oriented etching lines since they are basically too flimsy. We thus recommend that one avoids, if possible, inner layer cores that are thinner than 75 µm as our experience tells us that this 'design guideline' works well across our higher technology factory base."

"If a factory says it has laser drills and is thus capable of producing high-tech PCBs, it's rather like saying that all you need to do to become a new Michelangelo is to get yourself a hammer and chisel. It's just as important to know how to handle the plating process as to have cutting-edge plating equipment."

CHRIS NUTTALL, NCAB GROUP

If there's enough space on the board and the component is available with different pitches, Kenneth also recommends to select a component with a larger pitch since it reduces the complexity of the board and saves costs.

"Smaller components may be less expensive to purchase or more readily available, but this approach might render the board unnecessarily expensive in relation to its end application. Opting for small components, usually, increases the complexity of the circuitry, and therefore the board will increase in cost also.

This is where the customer should work with NCAB to determine if the design needed for such components is a cost effective one – is the reduced cost associated with buying more readily available, but more complex, components balanced with a potentially more expensive PCB? If, for example, it is to be used in mobile phones destined

The laser drill is used in HDI production.

for the consumer market, or in low volume production.

We are also seeing more PoP (Package on Package) type components being used in the industry. You should carefully check whether the assembly house is familiar with the technology and the extra costs it might involve. Of course, smaller components are space saving, which could produce a cheaper board, as long as it doesn't mean making it more complex, with several levels of micro vias or adding buried structures etc. One invariably has to weigh up the space contra complexity issues at the design phase.

"NCAB makes a point of being involved right at the very start in order to help customers find the right solution. One has to realise that there are real differences between producing prototypes and volume production." Explains Kenneth Jonsson. "If you focus on the wrong things from the start, it could jeopardise the entire project if you find that your design can't be applied in volume production. My recommendation is to initiate a 'seamless project' together with us at an early stage; in order to ensure that the board can be manufactured at a reasonable cost with the right level of complexity for the design and also for reliable yields." He continues.

"The advantages of turning to NCAB Group is that we possess the skills and knowledge both on the design and manufacturing sides. We know what the factories need in order to successfully deliver quality products, within realistic leadtimes. We know which factories are best at fulfilling different types of requirements. And we also know how to design boards that will give customers high yields and best in class quality end products." Concludes Chris Nuttall.

Questions around the world: What developments are you seeing on your market, specifically with regard to high-tech PCBs? How would you describe your customer's expectations and demands on PCB manufacturers within this area?

RUSSIA
VLADIMIR MAKAROV
Managing Director, NCAB Group Russia

– For a long time, ordinary double-sided PCBs were the norm on the Russian market. In recent years however, the situation has changed markedly. It isn't really surprising, since the market has been heading towards miniaturisation and increased functionality in electronics products, which calls for more advanced, denser boards. Achieving the qualities the market is looking for in PCBs is a challenge mainly for skilled designers. The key has been to work closely with our customers to help them develop more modern and competitive products.

MACEDONIA
SLOBODAN SHOKOSKI
Managing Director, NCAB Group Macedonia

– The economic recovery in the Balkans is gathering momentum, although it's still somewhat uneven. The main drivers are the advanced economies, such as Slovenia, while progress is slower than expected in other areas. Over 60% of our orders are for high-tech PCBs, most of them from contractors in the telecom industry, where quality and reliability is a priority. Our biggest challenge is that we need to put a great deal of time into meeting the exact needs of our customers.

GERMANY
OKTAY CAN
Key Account Manager, NCAB Group Germany

– Our customers are leaders within the high-tech segment, who demand increasingly complex solutions, both in terms of applications and technology. The biggest growth in demand that we are seeing is thus for more complex PCBs – at the very limits of what is possible to achieve. At the same time, customers are demanding more with regard to quality, reliability and lower costs. It takes time to develop the appropriate competence in order to manufacture such advanced boards, and therefore it's important we take great care in choosing appropriate suppliers. Our business builds on our ability to meet the high demands our customers place and deliver quality they can rely on, at the right price.

”8 design tips for HDI”

COMMON DESIGN PROBLEMS REGARDING HDI	PRODUCTION PROBLEMS DEPENDING ON THIS	BEST SOLUTION
Dielectric too thick for laser vias	Increased time for laser drilling, lower productivity. High risk for voids in the plating process, especially in the bottom of the microvias. Increased price for the PCBs due to reduced yields.	Use an aspect ratio under 0.8:1.
Too small microvia size	Increased risk for the microvia to be blocked by unknown material and therefore won´t be plated satisfactorily. High risk for poor plating of the microvia, especially in the bottom. Increased price for the PCBs due to reduced yields.	Use microvias of 100 µm with an aspect ratio under 0.8:1 for microvias intended for copper filling. Use microvias of 125 µm and with an aspect ratio under 0.8:1 for microvias where copper filling is not a requirement.
Too tight geometries in the form of too small capture and target lands for the microvia	If the target land is too small, the risk will increase for partly missing it (so called overshoot), and material adjacent to the pad will be burnt down to the next layer. If the capture land is to small, it is a risk for the land to be broken, which is not acceptable to any class in IPC-6016.	If possible, use a start pad that is 200 µm larger than the microvia. If possible, use a stop pad that is 200 µm larger than the microvia. At tighter geometries consult NCAB.
Too tight demands on permitted dimple on copper filled microvias	Increased price for the PCBs due to reduced yields.	Place the requirement of dimple to a maximum of 25 µm.
Too tight demands on the thickness of overplating of plugged vias. (POFV or VIPPO)	Affects the flow of the process, at a reasonable thickness of the overplating all the vias can be drilled in the same operation, which makes the process much easier. If the overplating is too thick this will reduce the possibilities to produce outer layers with thin tracks/small isolation.	Set the requirements according to IPC-6012 class II and demand only ≥ 6 µm as overplating thickness.
Epoxy via plugging demands for too many different sizes of vias, this applies to both buried as for through vias	Hard to control that bubbles don´t occur in the final plug, and that there won´t be a problem with complete filling.	Only one size of the plugged vias are preferred, if more sizes have to be plugged, keep them within a range of 0.15mm.
Microvia placement	If microvias are placed directly into SMD surfaces, unnecessarily voids can arise in the solder joints at reflow soldering. The price structure increases if the micro vias are copperfilled.	Pull the microvias from the SMD surfaces if possible. If there is no place to do alternative 1, place the microvias right into the pad and demand for them to be copperfilled.
Too small distance between the staggered holes and the microvias – microvias or microvias – buried vias	If the staggered microvias are placed too close to each other, there is a risk that the overlaying hole can intrude on the underlying one with bad plating as a consequence. This can be solved by copper filling of underlying microvias or overplating if buried vias, all this means increased cost and risk.	Regarding microvia-microvia, keep a distance of 0.30 mm between holes if possible, if not, go down to 0.25 mm. Example: 0,10 mm microvia and 0,25 mm buried hole gives 0,475 mm and 0.425mm in center to center distance.

Skills and collaboration are prerequisites for a sustainable product

HANS STÅHL
CEO NCAB GROUP

The main article in this issue of In Focus looks at the many questions that can arise with regard to HDI boards. There is a great difference between an HDI board and a simple double sided PCB. The differences are apparent all the way from the initial design stage right through to manufacturing and purchasing. As the article points out, a factory's equipment is just one part of the production process. The skill and knowledge of its staff are just as important. However, one shouldn't avoid embarking on the HDI road, since the technology offers so many advantages, including above all, the ability to meet the market's demands for miniaturisation and reliability. It is vital that designers and buyers choose the right partner on this journey, a partner with the technical experience and grasp of both prototype and a volume production. This, to avoid the pitfall of designing a board that works well at the prototype phase, but not when it comes to volume production. It is also important to have several factories that are well established in the industry, so that we can always deliver the optimal solution, irrespective of the volumes involved.

However, the most important factor behind achieving an optimal design is make sure you work together with all the parties involved, i.e. the OEM companies, CAD designers, EMS companies and PCB manufacturers. All too often, when we receive an enquiry from our EMS customers, we find ourselves presented with a finished design and no time to make any improvements. There is a lot of time and money to be saved by implementing the right approach - most importantly you'll get a product that will last for decades!

NCAB Group in Social Media

For a few months now, customers and other interested parties have been able to follow us on Twitter and LinkedIn. We have also started a blog where we immerse ourselves in the versatile world of circuitboards! **» Twitter » LinkedIn » Blog**

You will find more PCB Design tips on our blog:

» PCB Design tips: Via-in-pad
BY KATHY NARGI-TOTH, TECHNICAL DIRECTOR, NCAB GROUP USA

Subjects we have covered earlier

Do read our earlier newsletters. You will find them all on our website, www.ncabgroup.com/newsroom/

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» Prototype manufacturing
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» Russia in from the cold
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Are we taking up the wrong subjects?

We are always looking for interesting subjects that we could take a more in depth look at. If there is something you would like to learn more about, or perhaps you would like to comment on anything we have written, do get in touch with us and tell us more.

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