

# Greatest Precision for Smallest Components

Reproducible machine settings ensure reliable injection moulding process at Cicorel

The Cicor Group is one of the leading suppliers of electronic assemblies worldwide. With its four divisions Printed Circuit Boards (PCB), Microelectronics (ME), Electronic Solutions (ES) and Asia, it assists numerous customers with the development and production of highly complex PCBs, 3D-MID solutions, film circuits and electronic modules. The group employs a total workforce of around 1,300 at twelve production sites at locations in Switzerland and Germany as well as Romania, China, Singapore, Indonesia and Vietnam.

At Boudry in Switzerland, there is a production and administration building which houses Cicorel SA, a company of the PCB Division, where the former Boudry and Unterägeri locations were jointly relocated with additional capacities. The PCB division specialises in the manufacture of printed circuit boards. It develops

and manufactures these on behalf of customers, from the idea to the product being ready for mass production. The product portfolio includes small-scale and large-scale series as well as standard and customised products. The PCBs are used in a variety of applications in all industries, from medical technology to communication technology, from watches to automotive engineering and other transport systems.

### Tailor-made technology adaptation

Cicorel places a great deal of importance on the ability to work with a cross-divisional approach in its development activities where required and to exchange know-how. Its current development project also involves several technologies. In 2011, a development group headed by Nouhad Bachnak was set up in Boudry with the task of putting 3D-MID technology into practice. Although Cicorel is new to in-

jection moulding, the implementation is worthwhile. "Many companies master one technology which they offer for applications that can be realised using that particular technology. We are looking at it from the opposite perspective. We know the applications from the area of electronics and we are thinking about the technologies we need to realise them, to optimise them or to make them suitable for use in other areas of application."

Bachnak about the advantages of the so-called Moulded Interconnect Devices (MID) for special applications: "3D-MID technology is only useful if you need to construct something involving the third dimension or if miniaturisation is required," he explains. "This is where classic printed circuit boards verge on their limits." At the same time, systems can be simplified, and the end result is a

The specially developed demonstrator shows the flexibility in designing geometries for 3D-MID; and all individual process steps can be tested specifically for each material using the test piece.



Photo: Cicorel



The IntElect 50-80 impresses many with its high accuracy both in product development and in mass production, and it covers all common sizes of 3D-MID elements.



The new technology offers numerous starting points to discuss details of this process (from left): Urs Kocher (Mapag), Nouhad Bachnak and Reto Leist, both from Cicorel, and Thomas Brettlich, from Sumitomo (SHI) Demag.



During the project meeting, Reto Leist explains that the set parameters will be reproduced by the IntElect with great precision and will allow flawless production.

One of the 3D-MID circuit substrates which are being developed and manufactured at Cicorel, in detail.

manufacturing process that creates the desired electronic circuit substrate in fewer steps and generally at lower cost. In Boudry, the basic material of the 3D-MID technology is a thermoplastic material doped with an organometallic compound. Around 40 types of plastic with various metal doping options have been released for the process of Laser Direct Structuring (LDS) by the patent holder LPKF Laser & Electronics AG. Amongst others, these include PC/ABS, PA or LCP which are already in use at Cicorel or which are currently being tested for future applications. For this purpose, Bachnak's team has developed a demonstrator that all process steps are tested and individual steps are demonstrated with.

After the injection moulding process, the main body is processed during the Laser Direct Structuring using an IR laser.

The action of the laser roughens the surface so that the metal coating will subsequently adhere well to the surface. At the same time, the additives are activated and the metal atoms will become the nuclei for the subsequent reductive copper-plating. Cicorel uses an LPKF infrared laser with a wavelength of 1064nm. The beam diameter is 80µm which means that every future track is traced twice to mark the full width. In series operation the technology is currently able to produce a track width of 150µm and similarly small spaces. The goal for 3D-MID technology is to achieve even greater miniaturisation and enable even smaller track widths.

In terms of component design, 3D-MID allows greater scope than classic PCB technology as the possible shapes are only restricted by the ways the laser can be guided within the three dimensions. One prime example is the creation of



aerials in hearing aids. Conventional aerial technology can be replaced by 3D-MID which can create the appropriate structure directly on the housing in a very space-saving manner. Once painted over, the structure is functional but no longer externally visible.

The third process step is the chemical plating where the conductor is built up in several stages. A base layer of copper is applied which is covered by a layer of nickel which is in turn covered by a final layer of gold. Once the metallisation has been completed, the circuit substrate can be equipped with components to produce a complete assembly.

**Purposeful selection of the injection moulding machine**

"From the very start, we had targeted the IntElect in terms of equipment," says Bachnak. "It was clear that we needed a high-precision machine for this type of technology – and the IntElect fulfilled all our requirements in this respect." Reto Leist, Manager of Injection Moulding Processing, already had some experience with the all-electric IntElect. The company therefore immediately contacted MAPAG Maschinen AG in Bern which distributes injection moulding machines from Sumitomo (SHI) Demag

Plastics Machinery GmbH in Switzerland. Leist brings over 15 years of experience in injection moulding of precision components to the team and is familiar with the high demands placed on the injection moulding machine, particularly by small components, small structures and high surface qualities. "Around 80 per cent of all our applications are small, and the plastic components involved must be up to the mark – not just in terms of size but also with a functionality that is stable and reliable in the long term even for the smallest tracks," explained Bachnak in detail.

The precision of the IntElect is also important for the surface quality of the end products because that plays a major part for laser structuring. "We optimise the surface quality by means of the injection conditions and we set the parameters appropriately," explains Leist. "Whatever settings we choose the injection moulding machine will realise accurately with outstanding repeatability." As the surface is the critical element, the prototypes and test pieces from new material batches are closely examined. "The surface layer of a component is crucially important for successful laser processing and subsequent metallisation," explains Bachnak. "We are only talking about 30

to 40µm, but they have a large impact.” Cicorel examines this surface layer regularly during the product development process by taking sections in order to be able to assess its quality. In Boudry, the development work does not involve any automation. This means that equipment and machines remain highly flexible and can be adapted speedily to new requirements. Depending on production volumes, automation does not become cost-effective until production starts and is therefore only realised at that stage. The development activities are performed in air-conditioned rooms but not in a clean room environment. “Before each laser operation, the component is cleaned of dust using air,” explains Bachnak. The laser system itself is equipped with a tilting rotary table so that the table movements can be adjusted individually for each component.

#### Efficient transition from development to production

For Bachnak, the IntElect is more than a guarantee for successful development. As the technology is relatively new to Cicorel there are no production lines as of yet. The IntElect installed in the Technical Center is already mass-producing fully developed circuit substrates

using 3D-MID in addition to test series and trial runs. “Operations that run smoothly here will be transferred to our production lines in China in the future,” he says. But they are not there yet as the required IntElect machines are yet to be installed in their plant in China. “The machines currently installed there are partly electric but they don’t come anywhere near the precision of the IntElect. Cicorel will therefore install the same type of machine in China so that the changeover of production can be achieved speedily and smoothly by transferring the parameters to the machines there.” That way, Cicorel will also ensure the same high product quality at the same time.

There are already two products being mass-produced at Cicorel at the moment, a third was started in November. The volumes are between 100,000 and several million per year, depending on the application they supply. One part that has already made it to mass production is a component for a plug connector used by Fischer Connectors SA. The connector combines so-called signal pins and power pins. Thanks to the particularly compact construction, Fischer was able to realise a design that was much

smaller than a standard product with the same number of contacts. Compared to a conventional product with the same dimensions, the new plug connector from the MiniMax range accommodates three times the number of contacts. The size of the finished plug connector is roughly the same as that of a pin board pin.

#### High-precision miniaturised components in mass production

What makes this possible is the way the pins are formed. Injection moulding is used to create two comb-like structures which are then fitted together. “This design trick fulfils two tasks at the same time,” explains Bachnak. “For one, it allows the creation of the extremely thin pins from LCP material. Secondly, the pins are slightly offset after the fitting together so that the required isolation distance between them can be realised in a very small space.” With this idea, the new type of connector accommodates 20 signal pins and four power pins in the smallest of spaces. The component itself weighs 0.2g and is produced with a 10+10-cavity mass production mould. The mould is manufactured by a company in Singapore which is part of the Cicor Group. “As the information flow takes place within the group, it is very intense and detailed, and our demanding requirements are realised to the letter,” says Bachnak about the collaboration.

“With applications such as this connector, the machine behaviour of the IntElect is a great advantage for us,” states Reto Leist. “As the profiles can be executed very accurately and dynamically, we are achieving outstanding accuracy. It is also important to us that each cycle is absolutely reproducible to ensure that the component quality remains consistent.” Each machine setting can be reproduced



Using a number of sections, the surface quality of the materials is examined as this has a major impact on the subsequent laser structuring.



Cicorel developed a new, injection-moulded LCP structure for the pins and created the tracks using 3D-MID for the compact design of this plug connector from the Fischer Connectors MiniMax range.

with 100% accuracy which facilitates the creation of a reliable injection moulding process for every component. "In the case of small components, we frequently work with an injection time of just 0.15s, for instance which needs to be adhered to without any deviation to avoid scrap." On the IntElect, the required adherence to such precise tolerance limits can be achieved thanks to very high sampling rates.

On the same machine, Leist also manufactures the 30g demonstrator with an injection time of 2.2s and a constant melt cushion of 0.22cm<sup>3</sup>. With config-

urations such as these, he is utilising the entire manufacturing range that the machine permits. The transfer of new parameters into the NC5 machine control system works perfectly, and after a tool change, a previously defined process sequence runs smoothly within a very short space of time.

A further mass produced item will protect card readers by preventing unauthorised access to customer data more effectively. The space-saving design of the protective cap replaces a structure where multiple PCB layers are stacked over each other. The third product also serves a se-

curity purpose; it will detect malfunctions in plant equipment to protect personnel from injury. In addition, Bachnak is currently overseeing some ten development projects.

Bachnak and Leist are both certain that the decision in favour of the IntElect has been worthwhile for Cicorel. The possibility of transferring production processes developed in Boudry 1:1 to further machines of the same type will allow the company to establish the newly implemented 3D-IMD technology fully and offer it to its demanding clientele around the world. ■

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