eXtreme Fast Control (XFC) and EtherCAT
in semiconductor manufacturing

Advanced packaging for 3D structures in the micrometer range

The printer is controlled by a C6017 ultra-compact Industrial PC (left); the energy required for the very high and short current pulses is provided by compact PS2001 power supply units (top).

Fonontech's Impulse Printing™ technology enables fast and non-contact 3D printing of wafers and printed circuit boards with conductive ink in the µm range.

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Electronic components and their structures are becoming smaller and smaller, making it all the more difficult to bond them. Conventional processes have long since reached the limits of what they can do in this area, but the Impulse Printing™ process developed by Dutch start-up Fonontech is bringing something new. It enables advanced packaging of semiconductors in 3D structures in the micrometer range. XFC technology components from Beckhoff and EtherCAT are key in this process.

The miniaturization of electronic components is making it increasingly difficult for conventional lithography-based processes to produce the bonding structures between components economically and reliably. "Conventional manufacturing techniques are reaching the limits of what they can do. With our Impulse Printing™ technology, we are taking things to the next level," says Fabien Bruning, CTO of Dutch start-up Fonontech B.V., based in Eindhoven.

The most important components in the process are silicon printing plates with micron-sized structures etched into them. These structures absorb the ink, which is applied to the substrates (printed circuit boards) during the next step. In addition to the etched conductor tracks, a heating structure is incorporated into the printing plates. Fabien Bruning explains: "A very high, short current pulse causes a tiny amount of the ink solvent to evaporate suddenly at the interface with the wafer. This blasts the ink off the wafer and onto the circuit board." Rob Hendriks, CEO of Fonontech, adds: "This process works really well even at a distance of over 60 cm, albeit with less accuracy at that point."

It is important that the printing process is contactless and fast. With a single current pulse, thousands of lines can be printed on a circuit board or other substrate in less than 1 ms. In addition, selective heating of the heating structures enables local alignment between the structure being printed and the substrate. The print head developed by Fonontech covers an area of 128 x 128 mm and can process all common inks. "This allows 300 mm wafers or areas of 600 x 600 mm to be printed in a short space of time, a format that is currently finding its way into back-end semiconductor assembly," says Fabien Bruning. With a flat heating plate and a stencil printing process, even larger structures can be produced in the same machine – for flat screens, as an example. Several print heads can be easily mounted next to each other for this purpose.

Fast and precise with PC-based control

The process is automated with PC-based control from Beckhoff. "Working with EtherCAT and XFC technology, Fonontech can synchronize and position the various modules of the machine in real time and with the necessary precision," explains Stijn de Bruin, sales engineer at Beckhoff Netherlands. When building the prototype, Fabien Bruning decided from the outset to use as many standard components as possible. As he explains, Beckhoff was chosen partly because of the flexibility that the TwinCAT 3 control software offers: "For example, we created algorithms in Simulink® that we execute in real time in TwinCAT." He also adds that there are many third-party suppliers who offer components with an EtherCAT interface. EtherCAT is also accepted by SEMI™ (Semiconductor Equipment and Materials International) as a communication standard (E54.20). For that reason, Fabien Bruning is also working on offering the print head as a separate module with an EtherCAT interface: "This would make it much easier for other companies in the semiconductor industry to integrate our technology into their machines." In addition, several print mod-

ules could then be combined to form a large print head that uses the distributed clocks of EtherCAT and XFC to print larger structures with higher precision.

Fonontech is currently using a C6017 ultra-compact Industrial PC that runs TwinCAT 3 PLC/NC PTP, TwinCAT 3 Target for Simulink®, and TwinCAT 3 HMI. The image processing application is currently run on a 19-inch C5240 slide-in Industrial PC. Fabien Bruning comments: "We could probably also run the algorithm on the C6017, but it's more convenient for it to be installed on a separate industrial PC during development."

The goal: 5 µm resolution

The prototype is currently printing multiple patterns measuring 10 µm in width on the substrates. "Structures as fine as these are beyond the abilities of most printing techniques," explains Rob Hendriks. Fonontech wants to go further than this, however, with the aim of producing lines measuring 5 µm wide with a sub-micrometer overlay error range. The exact timing of the processes required for printing with this high level of precision is based on eXtreme Fast Control Technology from Beckhoff. It is also necessary to migrate the current motion concept to an air-bearing sub-micrometer platform. "Thanks to the openness and flexibility of PC-based control, this works with the same hardware and control philosophy," states Stijn de Bruin.

In the beta version of the system, various motor variants and a handling platform are integrated alongside the air-bearing system. The compact drive technology for the low-voltage range up to 48 V – the EL72xx EtherCAT Servomotor Terminals and AM8100 Servomotors – has the potential to save additional space and outlay during installation and commissioning in this case. Fabien Bruning sees the integration of distributed controllers and Ether-CAT functionality as another interesting option: "There are not actually many alternatives to PC-based control on the market if you want to develop and market functional units with their own high-performance slave controller and integrated motion."

More information:
www.fonontech.com
www.beckhoff.com/semiconductor-industry

CTO Fabien Bruning (left) and CEO Rob Hendriks (right, both from Fonontech) with Stijn de Bruin (center, from Beckhoff Sales in the Netherlands), in front of the proof of concept for the technology.

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