

Tomorrow's screen technology

- LCD and plasma screens have now become commonplace and the next display generation is already on the horizon in the form of OLEDs that come in two variants: PLEDs and SM-OLEDs. The company OTB Display from Eindhoven, Netherlands, has developed a manufacturing technology that enables cost-effective production of these wafer-thin monitors. Last year, the company came up with a real world premiere: "plug-in" production facilities for PLEDs, equipped with PC control technology from Beckhoff.



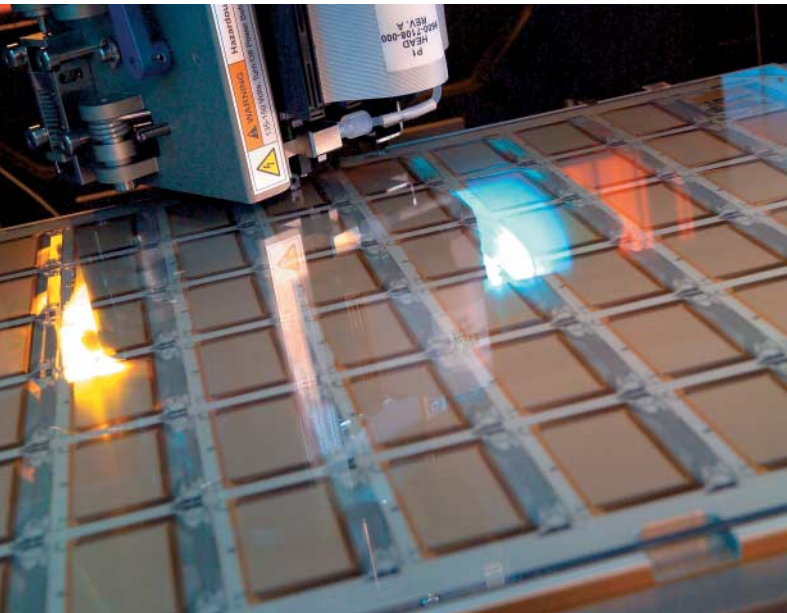
"Plug-in" production plant for PLEDs from OTB Display, Eindhoven, equipped with Beckhoff control technology.

Rollable computer screens that are so thin that they can be stuck as labels on wine bottles, for example, to show customers a video about the growing region. – Far flung vision for the future or reality? "With the new PLEDs, it is conceivable that such applications will become reality in five to ten years," said John Verwoerd, Operations Manager at OTB Display.

Slimline, flexible, self-luminous, orthochromatic and high in contrast – these are the benefits of the organic light emitting diodes (OLEDs). OLED displays are based on two different technologies that are already available on the market in a wide range of variants:

- | PLED (polymer OLED): organic LEDs based on longer-chain polymers that are applied in liquid solution,
- | SM-OLED (small molecules OLED): organic LEDs made up of vacuum-deposited small molecules.

Using advanced production technology, the "thickness" of OLEDs can be so small that they are barely visible with the naked eye: usually they are only about 500 nm thick. PLEDs are not only ultra-thin, they are also self-illuminating. PLEDs consist of polymers that let electrons pass in only one direction, causing them to il-



OLEDs are applied in layers on a glass plate using an inkjet printer.

Illuminated keyboard – one of the first OLED applications.

OLEDs are also used in MP3 players, PDAs and mobile phones.



illuminate. Among OTB Display's customers are companies from the international electronics industry producing such OLEDs. The know-how is so far advanced that the systems are fully equipped for the special OLED type the respective customer wants to produce. The production plants offered by OTB Display are therefore directly ready for production.

PC-based system control

When it came to deciding on a control system for a customer-specific PLED production plant (see text in box "PLED manufacturing process"), OTB decided to use a PC-based control system from Beckhoff with Industrial Ethernet and PROFIBUS DP networking. The system is controlled by 21 C6320 and C5102 type Industrial PCs, of which 20 are equipped with 2-channel FC3102 PROFIBUS cards, which means that the network features 40 PROFIBUS masters. Around 2,300 analog and 3,000 digital inputs and outputs are monitored using the Beckhoff I/O systems Bus Terminals (IP 20) and Fieldbus Box modules (IP 67).

The PLC and Motion Control functionalities are realized with the TwinCAT automation software. The system controls a total of 200 axes of both rotating and linear type. Via PROFIBUS, the system controls vacuum pumps, HF power supply units for plasma sources, servo-motors, linear motors with reversed operation in

PLED manufacturing process

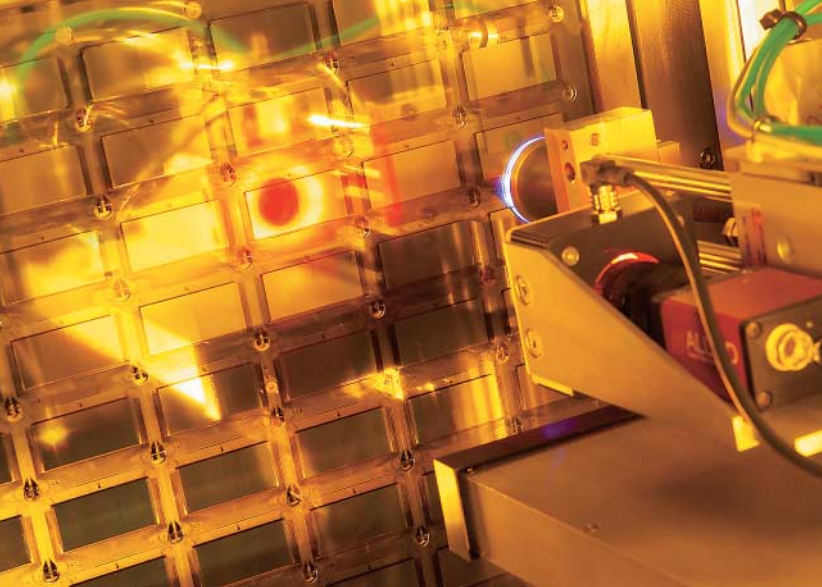
John Verwoerd, Operations Manager for OTB Display, explains the OLEDs production process using the example of a customer-specific plant for PLEDs: "The PLEDs we are talking about are designed as mass products. This means: For high production runs we have to be able to guarantee constant quality. Because PLEDs have dimensions in the nanometer range, controlled conditions are very important. Furthermore, we need to ensure that the end product is protected from oxygen and water. Up to now we used large cleanrooms, which are very expensive, and also very problematic in terms of transportation to the next production step. For this new plant we decided to use an in-line production process. That is, we use a transport system that operates in a hermetically enclosed space with cleanroom conditions. Part of the machine is under vacuum. We therefore have full control of environmental factors that could influence the end result. These conditions enable us to produce high quality."

Inkjet printer

"The line process starts with cleaning of the substrate or the glass plate onto which the PLEDs are printed," explained Verwoerd. "The glass plate has a certain surface structure with 'pits' that later serve as pixels. This machine produces PLEDs for MP3 players and other applications. The displays have 96 x 48 pixels; each pixel consists of three subpixels. One subpixel has a size of 79 x 234 micrometers. Once the plate has been cleaned, it is taken to the inkjet printer. This printer must fill each subpixel with a mixture of solvent and polymer with high precision. Very small droplets have to be applied exactly. High-precision positioning is required, especially since the whole process takes place on the fly!"

Polymers ensure high image brightness

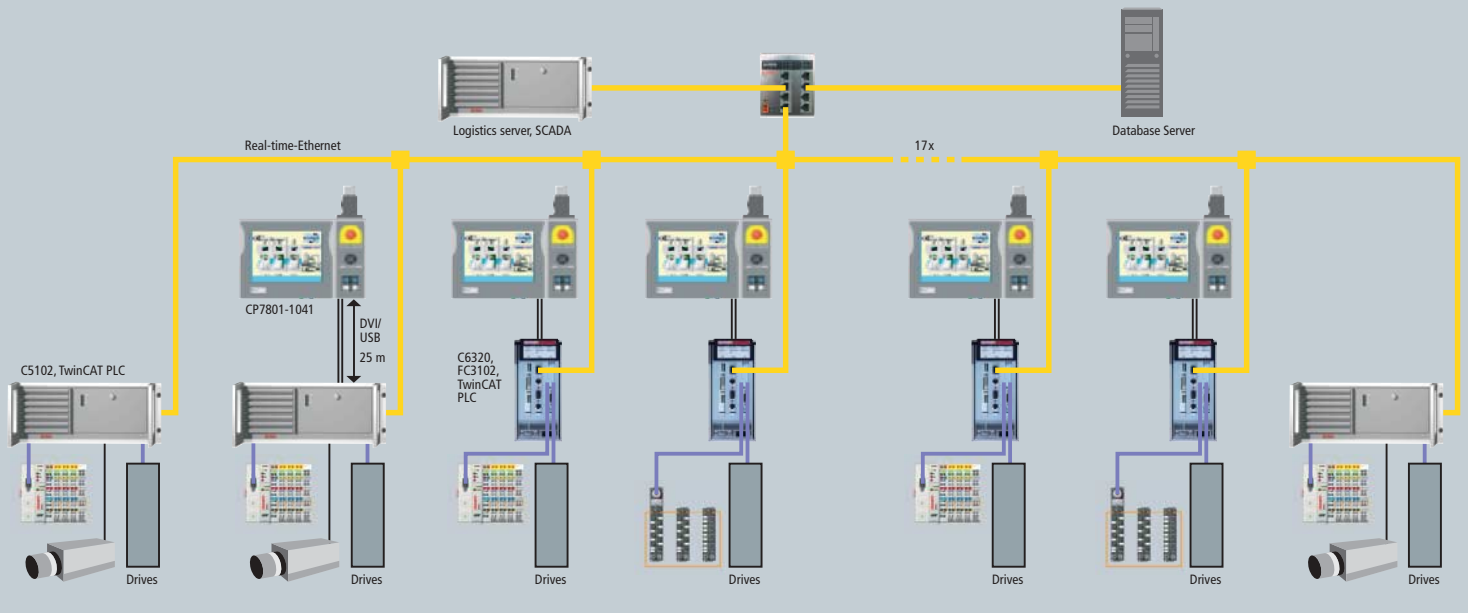
The glass plate is then baked in an oven, where solvent evaporates and is extracted. During the next step, the emerging PLEDs are taken to a further inkjet printer that applies a mixture of solvents and color components in three substeps. The color components are polymers in red, green and blue, which ensure a bright image. This is followed by another oven, where the solvent is removed from the product. The plate is then taken to a vacuum vessel, where a barium-aluminium cathode is vapor-deposited under a strong vacuum. This is used for injecting the electrons, which in turn are responsible for the luminous effect of the polymers. The cathode is surrounded with several layers of silicon nitride and organic compounds, a process the Operations Manager Verwoerd refers to as "thin film encapsulation." After the treatment in the vacuum vessel, the whole PLED is furnished with a further coating for protection against scratching and impact. In the last production step the PLEDs are cut from the glass plate.



The LEDs consist of several organic materials that are applied in thin layers. OLEDs are usually no thicker than 500 nm.

Organic Light Emitting Diodes (OLEDs)

The abbreviation OLED stands for organic light emitting diodes. OLEDs consist of different organic materials that are applied in thin layers with a thickness of usually no more than 500 nm. If an electric current flows through them, these materials illuminate strongly. This phenomenon is referred to as electroluminescence. Since the display is self-illuminating, no background illumination is required. OLEDs therefore have a significant advantage: they only consume about one third of the energy of current monitors. A voltage of 2 to 10 V is sufficient. Moreover, the monitors have a much greater viewing angle (179 degrees). OLED displays are also less temperature-sensitive and more cost-effective to produce. OLEDs with 2" image diagonals are currently mainly used in smaller mobile devices such as phones, cameras, PDAs or MP3 players, although OLED displays with a 1-meter image diagonal are also available today.



vacuum, and SMC valve terminals. In addition to the PROFIBUS protocol, the 20 Industrial PCs also process the real-time Ethernet protocol from Beckhoff. During operation, the PC controllers exchange information between the individual process steps in real-time via Ethernet. The data of a glass plate onto which the PLEDs are printed are transferred to the next PC, so to speak, where the next process step takes place.

SCADA tasks are also handled via Ethernet. To this end OTB Display uses MachineWorX 32, which is part of the Genesis 32 SCADA suite from Iconics. The system is used for monitoring the process and for transferring alarm signals, trends and status information to the user. Two further C5102 Industrial PCs record all data in a database. The operator can access the SCADA system via 18 customized Beckhoff Control Panels.

Internet connection enables remote maintenance

Production plants from OTB Display are used around the world – particularly in the Far East and the USA. In order to be able to provide local services, the Eindhoven-based company has branches in Singapore, New Delhi and Hilliard (Ohio). Systems can also be accessed directly via Internet. "From Eindhoven we offer continuous support for the production processes of our customers," said John Verwoerd. "When it came to selecting a control system, remote maintenance and control functions were particularly important criteria. TwinCAT not only enables us to visualize process data via a remote connection, we can also implement program changes online (i.e. without stopping the PLC) or monitor or control I/O points directly. The controllers are also connected to the office or ERP network and can be accessed via the Internet, naturally via a secure connection."

OTB Display uses a Beckhoff control system with Industrial Ethernet and PROFIBUS DP. Control tasks are handled by 21 Beckhoff Industrial PCs.

The glass plates with OLEDs are transported inside the machine.
Due to the in-line manufacturing process no costly cleanrooms are required.



Decision for Beckhoff

"The decision to use Beckhoff as supplier for control components was based on thorough deliberation," said John Verwoerd: "After a comprehensive selection of comparable products, we carried out hardware and software tests. From these tests Beckhoff emerged as the winner, not just because the company has the technical edge over its competitors. We were also happy with the price/performance ratio. Since it is a new machine, an important factor for us was modular expandability of the number of inputs and outputs. Flexibility and transparency were the winning features. Another important feature was the ability to start and shut down the software online. In this way we are able to install new program components without having to stop the machines. Local support through IAL, the Beckhoff partner in the Netherlands, was another important factor." Having successfully developed PLED production machines, OTB Display is currently developing machines for SM-OLEDs.

→ OTB Display www.otbdisplay.com

→ Industrial Automation Link BV www.ial.nl