

EtherCAT ensures maximum precision in lithography system

## Beckhoff technology controls blue laser light

The lithography system uses shortwave, blue laser light to create tiny structures on masks for producing flat screens.

→ Kleo Halbleitertechnik GmbH, based in Tettngang, Germany, produces state-of-the-art lithography systems for masks used in the production of LCD screens. The systems create tiny structures using shortwave, blue laser light. Artec Engineering GmbH based in Baienfurt, Germany, dealt with automation of the high-precision processes using Beckhoff control technology.

The requirements for lithography systems are very stringent: They are supposed to quickly, reproducibly and cost-effectively produce large quantities of high-precision masks with sizes up to 4 m<sup>2</sup>. A key requirement is the positioning accuracy of the laser beam. This is based on a low-vibration machine frame with high-precision geometry, robust and fast automation technology and exact measured value compensation.

Tobias Reiter, managing director of Artec Engineering GmbH, comments on the company's decision to utilize Beckhoff as the control equipment platform: "Our choice of PC-based automation technology from Beckhoff was based on the stringent requirements for system accuracy and robustness. Based on our own experience we knew that this system is capable of meeting high demands in terms of performance, stability and control characteristics."

In parallel, Kleo carried out market research and concluded that Beckhoff technology can achieve high velocities without interfering side effects, such as vibrations. Stefan Scharl, lithography system product manager at Kleo, said: "Follow-

ing our own research, the results of a study undertaken by FISW Steuerungstechnik GmbH in cooperation with the University of Stuttgart on the issue of drive dimensioning for a laser lithography system, and the recommendation by Artec, we had absolutely no doubt that Beckhoff technology is the right choice for us."

### Mechanical design is the basis for precision

The machine frame consists of a vibration-absorbing granite base that is manually ground with a precision of 2 μm, an air-suspended granite gantry and two air-suspended slides. The laser and an auto-focus system are mounted on the slides, which move the laser diodes longitudinally over the substrate with a velocity of 1 m/s and an acceleration of 10 m/s<sup>2</sup>. The three-ton granite gantry moves the unit in transverse direction with a positioning accuracy of 2.5 μm. Piezo systems control the focus and the lateral offset of the laser beam. To produce the required structure, the laser beams are variably pulsed during the motion.



AX2xxx Servo Drives  
for controlling highly  
dynamic linear motors

### Top speed with EtherCAT

At the core of the control system is a Beckhoff C6140 control cabinet Industrial PC with Windows XP Professional operating system and TwinCAT automation software. "Fast data transfer and processing are prerequisites for precise laser positioning. Therefore, we only use high-performance components such as the C6140 IPC, EtherCAT as the bus system and EtherCAT Terminals," said Tobias Reiter. Stefan Scharl added: "This enables us to achieve short sampling rates, short cycle times of around 50  $\mu$ s and stable real-time capability as the basis for high-precision positioning of the laser beams."

Each axis of the lithography system features a Fieldbus Box with a separate cable to the control cabinet. "This reduces the cabling effort and trailing cables, which is a particularly important factor for us", said Stefan Scharl. "We seek to limit trailing cables to glass fiber in order to reduce the scope for mechanical faults." "We use PROFIBUS for interfacing the Fieldbus Box modules and control units, including the PC and handheld devices. Thanks to the openness of EtherCAT, other protocols, such as PROFIBUS, can easily be integrated via the Bus Terminal system," said Tobias Reiter.

### High-precision positioning with Drive Technology from Beckhoff

"Linear motors are used for moving the gantry and the slides, while parts of the auto-focus system are driven by a servomotor. The motors are driven by digital AX2xxx Servo Drives from Beckhoff. In combination with TwinCAT automation software, we are able to position the laser precisely and with high repeat accuracy", said Tobias Reiter. "Notwithstanding the highly dynamic slide movement, we achieve uniform motion with a velocity tolerance of less than 0.01 m/s after a short acceleration phase." The linear motors are counter-rotating. "In this way we avoid high torques and can compensate the impulse," said Stefan Scharl. "In order to prevent jamming, the two electrically independent linear motors in the gantry are synchronized with a precision of 5  $\mu$ m through coupling via TwinCAT NC PTP."

Each movement of the gantry and slides requires activation and deactivation of the air bearings. "This must happen quickly, precisely and without change in position," said Stefan Scharl. "The controllers from Beckhoff meet this challenge. They are robust enough to avoid peaks even during the transition from friction-free to friction status."

Length measurement sensors monitor the current gantry and slide positions, and the measured data are processed directly by the Servo Drives. Interferometers

measure the current position of the laser beams. The position data are analyzed in the measured value compensation unit and serve as a basis for controlling the piezo systems for positioning the laser beams. "Even the integration of external drives, such as the piezo systems, into the automation solution with Beckhoff components does not lead to a reduction in the performance of the overall system," said Stefan Scharl.

"Thanks to small dimensions, integrated EMC filters and pluggable connections, we can simply install the Servo Drive in the control cabinet," said Tobias Reiter. Due to the heat sensitivity of the position instrumentation, the power electronics are located in a control cabinet outside the cleanroom. "To ensure an efficient exposure process, the glass fiber must not be too long. A second control cabinet containing the laser fiber coupling and the instrumentation is installed in the cleanroom close to the system and travels in parallel with the gantry during the process," said Stefan Scharl. The linear motors for the gantry and the drives for the control cabinet are coupled as master and slave axes via the PLC controller.

### Fit for series production through flexibility

An important success factor for series systems is flexibility. "Thanks to the modularity of the Beckhoff I/O system subsequent extensions, modifications and reconfigurations are easy to implement. This enables us to deal with customer-specific modifications, such as changing the number of light sources without trouble," said Stefan Scharl. Tobias Reiter added: "In addition, we created many features, such as safety functions, with software instead of hardware: Through the introduction of safety terminals in the Bus Terminal system, we can easily implement safety functions, such as emergency stop and safety door circuits or other modifications by adapting or replacing the software."

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