HEIDENHAIN INFO

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Semiconductor & Metrology

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High-Precision Drives for the Optical Industry

Lithographic processing in the semiconductor industry requires aspherical lenses up to 500 mm in diameter, which permit extreme reduction. The requirements placed on grinding machines to manufacture these lenses have to be very stringent to attain faultless results in surface machining. The drives built into the grinding machines therefore have to be highly precise. Schüssler-Technik offers torque motors (Figure 1) that enable high-precision grinding of mineral lenses, partly thanks to their integrated HEIDENHAIN angle encoders.

Schüssler-Technik in Pforzheim, Germany, is divided into two divisions. The first division manufactures primarily milling, bending and laser soldering machines for the manufacture of eyeglass frames. The second is occupied with the R&D and sale of direct drives. It was founded 14 years ago from the desire to replace the transmission by direct drive in its special machines for eyeglass manufacture in order to be able to position more quickly and precisely as well as mill surfaces without leaving vibration marks.

Fig. 1 In some areas, the highly accurate torque motors can replace hydrostatic drives

At the time, there were no torque or linear motors on the market that satisfied the demands of the company in Pforzheim. So the owner, Bernd Schüssler, decided to develop direct drives right in his own company. "For about six years now," says Ullrich Gäbel, Head of R&D for direct drives at Schüssler-Technik (Figure 2), "we've been offering other companies our customer-specific torque and linear motors as well as medium frequency spindles. Our revenue from this division, which today is approx. 30 % of our total revenue at Schüssler-Technik, shows that the market recognizes our efforts here." The following example of a grinding machine for the semiconductor industry shows how powerful these drives are today.

Pulsation-free iron-core torque motors

The manufacture of aspherical lenses for lithographic processes in the semiconductor

continued on next page

Contents...

Did You Know...

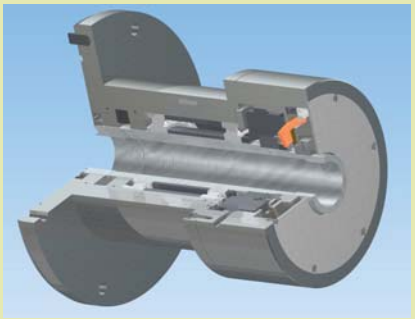
...that a Numerik Jena KIT R rotary encoder is an important component in the assembly of a highly effective rotary vacuum seal system manufactured by **Ferrotec (USA) Corporation**.

Specifically, the Numerik Jena component is used in FerroTec's FerroDrive motor-integrated vacuum rotary feedthrough product. These FerroDrive systems provide vital precision rotation sealing in a vacuum, which is necessary for assembly and processing applications in industries such as semiconductor, LED, solar cells and aerospace.

"Our FerroDrive motor-integrated feed through systems are designed to provide an integrated motor/seal subassembly for use in high vacuum manufacturing processes," said Tom Black, Ferrotec Engineering Manager. The Numerik Jena KIT R modular encoder and disk hub assembly components assist this Ferrotec system by tracking the specific position and speed of the shaft that actually penetrates a vacuum chamber and rotates.

"We appreciate the dependability of the Numerik Jena encoder in this system which provides us with a speed accuracy of ±0.1% and high stability and quality signals for smooth velocity control," continued Black.

The Numerik Jena KIT R rotary encoder series is known for its compact size, easy installation and signal interpolation of up to 100x. Through dynamic offset and amplitude control, high interpolation accuracy is achieved and further reduction of sensitivity to contamination is realized.



High-Precision Drives for the Optical Industry

continued from Page 1

industry is a particular challenge to the production process. The grinding machines used here and their components need to satisfy very demanding requirements. A well known manufacturer of grinding machines therefore uses the HGE pulsation-free torque motors from Schüssler-Technik.

Fig. 2 According to Dipl.-Ing. (FH) Ullrich Gäbel, "The quality of the position information directly affects positioning accuracy and rotational speed stability. That's why we use the highly accurate ERA 4000 angle encoder."

The advantage of iron-core torque motors over ironless motors is that they offer greater higher power density. However, a disadvantage of this type of motor is that the magnets and the slotted sheet metal normally generate latching forces that can be measured as pulses on the motor shaft. They would cause short-wave flaws when grinding the mineral lenses that would render the lenses useless.

In spite of this disadvantage, Schüssler-Technik has been constantly improving the motors for many years in order to be able to employ iron-core motors with high power density even in applications with the highest accuracy requirements. Thanks to a multi-pole design, an optimized sheet-metal and stator winding technology as well as special stator sheets and magnets, the latching forces of the water-cooled motors are hardly measurable today.

The quality of bearing, besides the reduction of the latching forces, is of decisive significance for the quality of the drives because both quantities determine the influence on the pulsation height of the motor axis. Schüssler-Technik has therefore developed its own axial-/radial roller bearing with a bearing pulsation of less than 0.01 µm. Such a small bearing pulsation is otherwise provided only by hydrostatic bearings. This hardly measurable bearing pulsation is attained through a very high quality of the bearing raceways and through minimal error in the roller geometry. The result is an iron-core torque motor with high power density whose total axial axis pulsation (pulsation by bearing and motor) is less than 0.02 µm.

A further important requirement in the use of grinding machines to manufacture mineral lenses with diameters up to 500 mm and weights up to 50 kg for the semiconductor industry was that the motor bearing has to be made extremely tilt-resistant. This made it possible to keep the maximum tipping error to 0.2 µm thanks to weight transfer during motor operation. The maximum axial and radial runout of the axes is 0.3 µm.

To be able to operate such high-accuracy drives at their best performance requires equally accurate measuring devices. This is why Schüssler-Technik has placed its bets on the ERA 4000 series modular angle encoders from HEIDENHAIN, which feature the high-accuracy measurement of the angular position with an accuracy of a few angular seconds.

Angle encoders without integral bearing

Ullrich Gäbel remembers, "We used to have another encoder in the motors. But because of the growing requirements for accuracy, we then decided to use the ERA 4000 from HEIDENHAIN. Besides the good characteristics of the angle encoder such as its accuracy and signal quality, years of good experience with the HEIDENHAIN experts in other products also played an important role. We've been working successfully with HEIDENHAIN for over 20 years."

The ERA 4000 series modular angle encoders from HEIDENHAIN are supplied as separate components: the scale drum and the scanning head (Figure 3). They are characterized by their compact dimensions and the high quality of position information in connection with a high number of signal periods. A regular graduation structure that carries the position information is applied to the scale drums. Since an absolute reference is required to ascertain the positions, the scale drums are provided with an additional track that bears distance-coded reference marks. Because the reference marks are individually spaced according to a mathematical algorithm,

continued on page 3

High-Precision Drives for the Optical Industry

continued from Page 2

the axis need only rotate by a small angle for the scanning unit to cross two successive reference marks and thereby ascertain the absolute position.

For Ullrich Gäbel, "One of the outstanding benefits of the modular design is that the scale drum can be placed very close to the bearing. The advantage is that the closer the scale drum is located to the bearing, the less the effect of error from any tilting in the bearing. The result is that the measuring accuracy is hardly influenced." The rigidity of the bearing therefore has an immediate influence on measuring accuracy. The more rigid the bearing, the more accurate the measurement can become.

To attain the high accuracy grades of the angle encoders, special methods were developed of applying the graduation structure to the drum. The realized graduation with high homogeneity and edge definition as well as single-field scanning with the optical filter structure enables consistently high signal quality of the output signals over the entire circumference of the drum. The subdivision accuracy values are therefore significantly better than ± 1 % of the signal period. Although signal interpolations of up to 4096 are usual, thanks to the high signal quality of these encoders, the servo controllers in the grinding machine for manufacturing optical lenses can be operated with 16 384-fold interpolation and with 24 000 lines on the encoder.

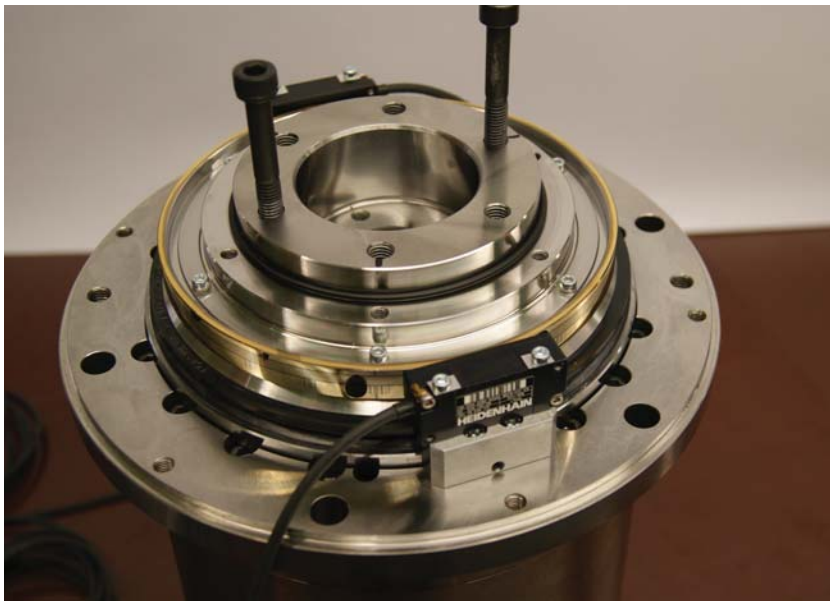


Fig. 3 A second measuring head is applied for alignment and is removed again afterwards

Schüssler adjusts the scale drum to a concentricity of 0.5 µm using and ND 287 digital readout, which is also made by HEIDENHAIN. "This enables us to align the scale drum to approximately the graduation accuracy of the encoder. This wouldn't be possible with a dial gauge," says Ullrich Gäbel. A second measuring head is applied for alignment and is removed again afterwards (Figure 4). This makes it possible to reliably transfer the specified high accuracy of the encoder to the motor. This high-precision alignment is necessary here because inaccuracies caused during the mounting procedure are immediately visible on the manufactured product. The alignment itself requires a maximum 20 minutes. For Ullrich Gäbel, "A further advantage is that we don't have to probe with the dial gauge directly on the encoder and that way we can prevent any damage."

Conclusion

Today, the HGE type customer-specific torque motors go into a wide variety of applications, for example as the table drive for hard machining, for mirror milling, as well as in measuring and grinding machines. The torque motors are available for shaft speeds from 200 to 600 rpm and torque values from 35 to 600 Nm. Ullrich Gäbel summarizes: "Today we've optimized our torque motors to the point that we're trying to replace hydrostatic bearings in areas where the forces approach the motors diagonally. This is the case, for example, in hard machining or in the milling of mirrored objects on machine tools. The resistance to tilt of our motors of certain sizes is now already higher than for comparable hydrostatic solutions. Now we are working on improving the damping."

Schüssler-Technik plans to continue using encoders from HEIDENHAIN in future developments, too. "The further development of our motors will require special solutions, too. So it's a great advantage for us that the ERA 4000 series encoders are also offered as customer-specific solutions, for example," explains Ullrich Gäbel. This enables them to agree on an optimal inside diameter of the scale drum for installing the encoder as close as possible to the bearing—as described above—in order to ensure the smallest possible measuring error when a bearing tilts.

Expanded Training Programs Now Offered

By John Thormodsgard, National Sales Manager, Semiconductor, Metrology and Medical Division

John Thormodsgard
National Sales Manager, Semiconductor, Metrology and Medical Division

HEIDENHAIN has expanded two of its longstanding training programs to better serve our customers this year. Our Lunch & Learn program provides customer-site technical and product training for OEM customers while our distributor training program provides in-depth product, application, and sales training at our facilities.

While the breadth of the HEIDENHAIN product line has long offered key advantages in providing a tailored product most suited to customer applications, the array of models and configurations can be overwhelming. Our Lunch & Learn trainings address this by offering presentations that are geared to specific needs of each customer. Topics often will include technical encoder and measuring principles, product overviews, or the results of our fundamental research as often published in HEIDENHAIN white papers. This information is provided by our sales and product managers over lunch; the casual atmosphere very often leads to an active question-and-discussion session. While we have offered such trainings periodically in the past, the interest in such sessions has increased with our product offering. Our presentation materials and focus on this have been expanded in turn.

Our distributor training program offers an intensive three-day training event at our facility. The topics above are expanded upon to include a broader array of our product offering as well as application and sales presentations. These are held at our Schaumburg, IL facility, allowing participants access to our hands-on demonstration room as well as the opportunity to meet more of our staff. A number of training programs are held periodically, including introductory and advanced trainings in metrology distribution, machine tool distribution, CNC programming, and IK5000 programming.

If you are interested either of these programs, please feel free to contact me or your regional sales manager for more information. We welcome your call.

Regards,

John Thormodsgard
847-519-3399

Technical Tidbit:

HEIDENHAIN Measuring Standards

HEIDENHAIN encoders with optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass or steel. The scale substrate for large measuring lengths is a steel tape.

HEIDENHAIN manufactures the precision graduations in specially developed, photolithographic processes. The following lists the five main graduation types offered on HEIDENHAIN encoders:

• AURODUR: Matte-etched lines on gold-plated steel tape with grating periods of typically 40 µm

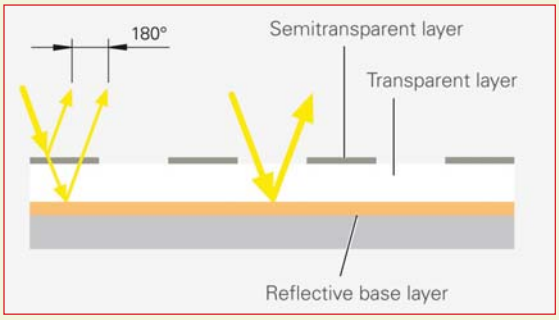
• METALLUR: Contamination-tolerant graduation of metal lines on gold, with typical graduation period of 20 µm

• DIADUR: Extremely robust chromium lines on glass (typical graduation period 20 µm) or three-dimensional chrome structures (typical graduation of 8 µm) on glass

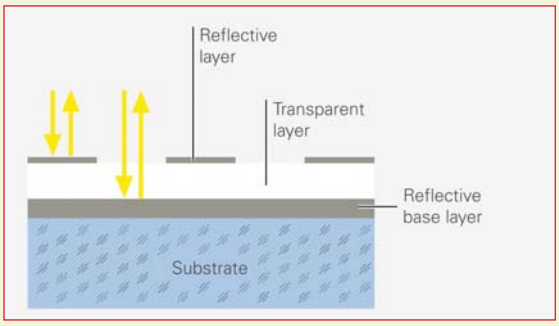
• SUPRADUR phase grating: optically three-dimensional, planar structure; particularly tolerant to contamination; typical graduation period of 8 µm and less

• OPTODUR phase grating: optically three-dimensional, planar structure with particularly high reflectance; typical graduation period of 2 µm and less

Along with these very fine grating periods, these processes permit a high definition and homogeneity of the line edges. Together with the photoelectric scanning method, this high edge definition is a precondition for the high quality of the output signals.



METALLUR



SUPRADUR

The master graduations are manufactured by HEIDENHAIN on custom-built high-precision ruling machines.

For more information, contact:
Kevin Kaufenberg, HEIDENHAIN Product Manager
847-490-0387

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For more information about HEIDENHAIN and any of the products or services mentioned here, please feel free to contact us.

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The Measure of Excellence

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