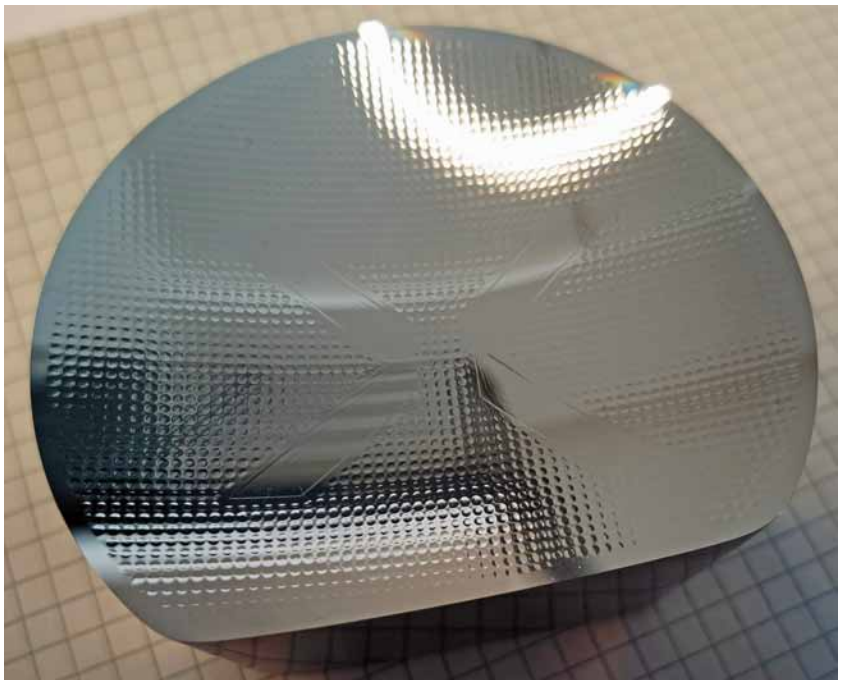
Lenses, mirrors, semiconductor technology, lasers, prototypes ...

Ultraprecision machining of metals and plastics



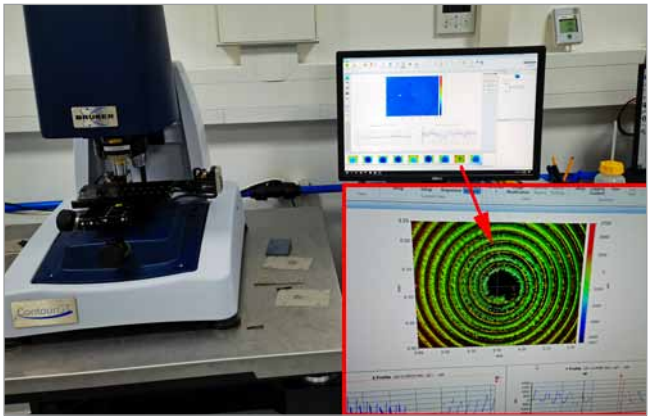
Experimental mold insert made of hardened tool steel with microstructure. The high gloss is achieved without manual reworking
(Photo: Klaus Vollrath)

For many optical components, such as lenses or mirrors, the requirements for the accuracy of the contours and the quality of the surfaces are up to a power of ten more stringent than for other micro production processes. Fractions of a micrometer or surface roughness values in the single-digit nanometer range are required. In addition, non-linear geometries and sometimes even free-form surfaces are usually involved. For such tasks, a company specializing in relevant engineering and services relies on a five-axis milling machining center with an air-bearing high-frequency spindle.

Proud owners: The two managing directors Dr.-Ing. Benjamin Bulla (left) and Dr.-Ing. Olaf Dambon
(Photo: Klaus Vollrath)

"We've specialized in ultra-precision machining of metals and plastics," explains Dr.-Ing. Olaf Dambon, managing director of son-x GmbH in Aachen (Germany). Son-x was founded in 2011 as a spin-off from the Aachen-based Fraunhofer Institute for Production Technology IPT and has hitherto experienced rapid growth.
The initial spark was the development of an actuator that causes a cutting edge made of a diamond single crystal to vibrate at ultrasonic frequency. This cutting edge is used as a turning tool on ultra-precision lathes with air bearings. Thanks to the vibration, the contact time of the cutting edge with the workpiece is extremely short during each cycle, thus efficiently suppressing thermal or chemical reactions between the cutting edge and the workpiece. This makes it possible to use the diamond cutting edge even when machining steel. Applications include mold inserts to produce lenses by injection molding. The "UTS2" system, consisting of an ultrasonic generator and tool holder, was developed for use on precision lathes. Ultrasonic spindles are also included in the range as a further product family.

The original business model of son-x was the development of tool holders for ultra-precision turning using diamond tools. The holders vibrate in the range of ultrasonic frequencies
(Photo: Klaus Vollrath / son-x)



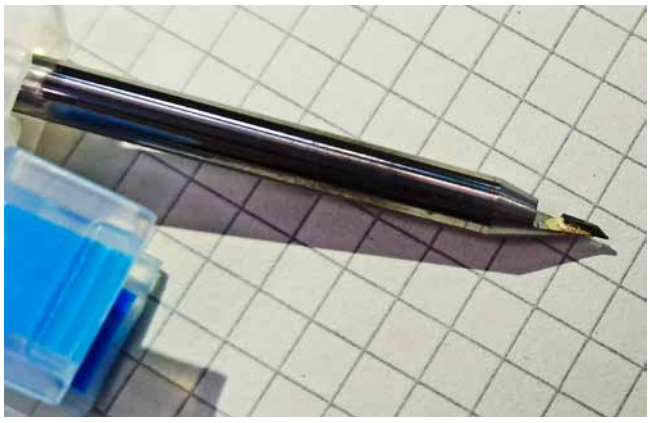
Son-x has numerous systems for surface quality control, such as this interferometer (Photo: Klaus Vollrath)

SERVICE PROVIDER FOR ENGINEERING AND PRECISION MACHINING

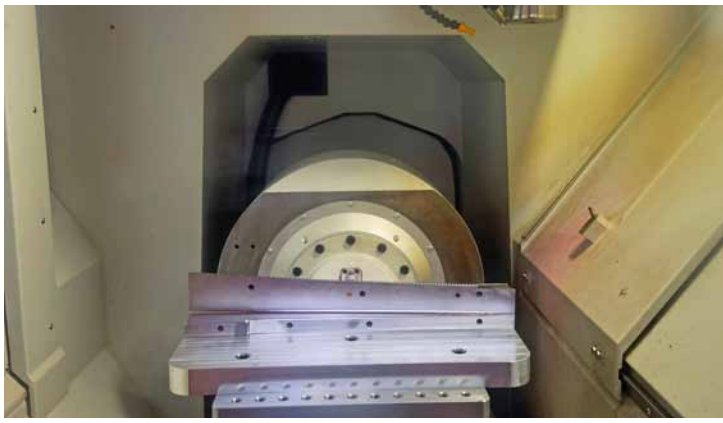
"However, the optimal use of these solutions also requires a great deal of know-how, which is why most customers prefer to purchase finished components or prototypes," adds Managing Director Dr.-Ing. Benjamin Bulla. To this end, in addition to comprehensive engineering expertise in the high-precision machining of components, corresponding manufacturing capacities have also been built up. Son-x manufactures metallic components made of various alloys, including high-strength steels, as well as parts made of – mostly crystal-clear – plastics. The quantities range from single pieces to several hundred per year, the dimensions extend from a few mm to diameters of 500 mm, for example in the case of metallic mirrors. Applications include optics, laser technology, sensor technology and astronomy, as well as molds for light guiding and lighting systems for the automotive industry. In addition, they may encompass the production of optical arrays as well as pure research projects such as making mirrors for the Wendelstein-7-X facility for nuclear fusion experiments at the Max Planck Institute in Greifswald.

VENTURING INTO 5-AXIS MILLING

"Over time, we began to receive more and more requests for parts whose geometry was too complex to be produced by turning," recalls Dr. Dambon. To find a machine suitable for this purpose, a specification sheet was drawn up and a test geometry designed. Then the process of identifying possible suppliers began. Contact with Röders was established in 2016 at the Optatec trade show,



Milling tool with diamond tip for machining non-ferrous metals on the Röders milling machine (Photo: Klaus Vollrath)



View into the working area of the RXP 601 DSH. Clamped onto the rotary swivel table is a mold insert for light guides, such as those used in automotive interiors (Photo: Klaus Vollrath)

where the company had shown off high-quality machined mold inserts, among other items. In addition to Röders, four other machine manufacturers active in the field of high-precision machining were shortlisted, including three Japanese manufacturers. After intensive preliminary discussions, the candidates were finally provided with the CAD data for a test component that exhibited the most significant challenges of the intended tasks. In this comparison, the test part machined by Röders performed best. Since the initial consultation had also been convincing, the Soltau-based machine manufacturer was awarded the contract for a 5-axis milling machining center of the type RXP 601 DSH.

SPECIAL FEATURES OF THE RÖDERS RXP 601 DSH

"In view of our precision requirements, the factors of rigidity, smooth running and thermal stability were high on the list of priorities," says Dr. Bulla. Compared to the minuteness of the details to be machined and the microtools used for this purpose, the Röders milling machine, which is also suitable for the toughest roughing operations, appears rather oversized at first glance. However, it was precisely this mass and the measures taken by the manufacturer to ensure the highest precision of the machining results that had an exceptionally positive effect in this case. When machining complex optical arrays with hundreds of tiny cavities for lenses, a job sometimes takes more than 50 hours, and throughout this time, the machine's reference point must remain extremely stable to ensure the exact alignment of each lens. The RXP 601 DSH achieves this, he says, thanks to its linear direct drives, high-precision linear guides and frictionless weight compensation for the Z-axis, combined with highly accurate optical scales. With its high-end Racecut functionality, the control system compares the actual and target positions of all axes 32,000 times a second, correcting even the most minimal path deviations as they occur. Exceptional thermal stability is provided by a temperature control medium that circulates through all important components of the system and whose supply temperature is kept constant with an accuracy of ±0.02K.
Of course, the temperature of the hall in which the plant is located is also kept stable by an air conditioning system. Finally, as the icing on the cake, the machine is equipped with an air-bearing, vector-controlled Levicron spindle with up to 60,000 RPM. Thanks to its smooth running and high damping, this spindle makes it possible to produce top-quality surfaces in all materials. As this eliminates the need for manual reworking, it also prevents the related and often unavoidable distortion of the surface or geometry. Another essential prerequisite for top results is the high accuracy of the machine's path planning. In combination with NC programs calculated with the highest accuracy by a powerful CAM system, the desired CAD geometry is reproduced in the workpiece without falsification or wear.

The employees quickly got to grips with the new control system, as it is very intuitive to operate (Photo: son-x)

The fact that Heidenhain®-compatible cycles can be used on the control was also highly appreciated (Photo: Klaus Vollrath)

EXPERIENCES MADE DURING DELIVERY, FAMILIARIZATION AND TRAINING

"The machining center was delivered in October 2018 and could be put into operation within just one week," Dr. Dambon reports. The four-day training also went with similar smoothness. The employees quickly got to grips with the new control system as it is very intuitive to operate. The changeover from the Heidenhain® control system, with which they were already familiar, was pleasingly easy. In this context, it was of course helpful that the Röders control can also be programmed directly with Heidenhain® cycles. Data transfer from the CAM software used at son-x turned out to be easily feasible. Advice and support during the ramp-up phase were equally satisfactory. If sometimes problems arose, assistance was provided quickly and with a high level of competence. There was only one malfunction on the machine itself due to a switch problem, but this was quickly diagnosed and rectified with the help of remote maintenance. Throughout more than two years of cooperation, Röders has proven itself as a reliable partner.

HIGHLY SATISFIED WITH THE RESULTS

"Since we have many long-running jobs, the long-term stability of the reference point is also crucial for us, in addition to the precision that is possible within a short time," reveals Dr. Bulla. And on this point, he says, they are really impressed with the Röders system. For example, they had to machine molds for arrays of hundreds of plastic lenses whose shape deviation was allowed to be a maximum of 316 nm, i.e. 0.316µm (!). This value was reliably maintained even after 50 hours of use, even for the last lens in the array. The company was also pleasantly surprised by the speed of operation. In the meantime, so many orders for parts are nncoming in that the machine is almost fully utilized. "We are very satisfied, the expected results are there and have even been exceeded in some cases," says Dr. Bulla, summing up his experience.

Klaus Vollrath, b2dcomm.ch

Addresses
son-x GmbH,
Gewerbepark Brand 15, D-52078 Aachen, Germany
Tel. +49-241-927800-10, F.ax +49-241-927800-99,
info@son-x.com, www.son-x.com

Röders GmbH,
Gottlieb-Daimler-Str. 6, D-29614 Soltau, Germany
Tel. +49-5191-603-43, Fax +49-5191-603-38,
hsc@roeders.de, www.roeders.de

THE RÖDERS RXP 601 DSH

The Röders RXP 601 DSH 5-axis HSC milling machine has been designed to meet the highest accuracy requirements while at the same time providing high metal removal rates, especially when machining hard materials. It features frictionless linear direct drives which, in combination with 32 kHz controllers in all axes, enable both highly dynamic and high-precision machining. An essential prerequisite for this is high-precision optical scales in all axes – when it comes to precision, no compromises are made. Due to its accuracy and dynamics, the machine can also be used for coordinate grinding. In addition, the Z-axis features a patented frictionless vacuum weight compensation.

To ensure maximum thermal stability, the machine has a sophisticated temperature management system. The temperature of the medium flowing through all major system components is controlled with an accuracy of ± 0.1 K, or ± 0.02 K for certain applications. Another special feature is a dedicated control system based on PC technology, whose functionalities are precisely tailored to the specific tasks of HSC high-precision milling or coordinate grinding. Since Röders has developed the control system itself based on industrial PCs and the Windows operating system, updates of both the hardware and the software are available on request at any time, so that obsolescence of the machines on the part of their control system is virtually impossible. In the current release of the control system featuring the Racecut function, the correction of path deviations takes place with the exceptionally high sampling frequency of 32 kHz in each control loop. This enables significant reductions in machining time while at the same time ensuring optimum surface quality. <<