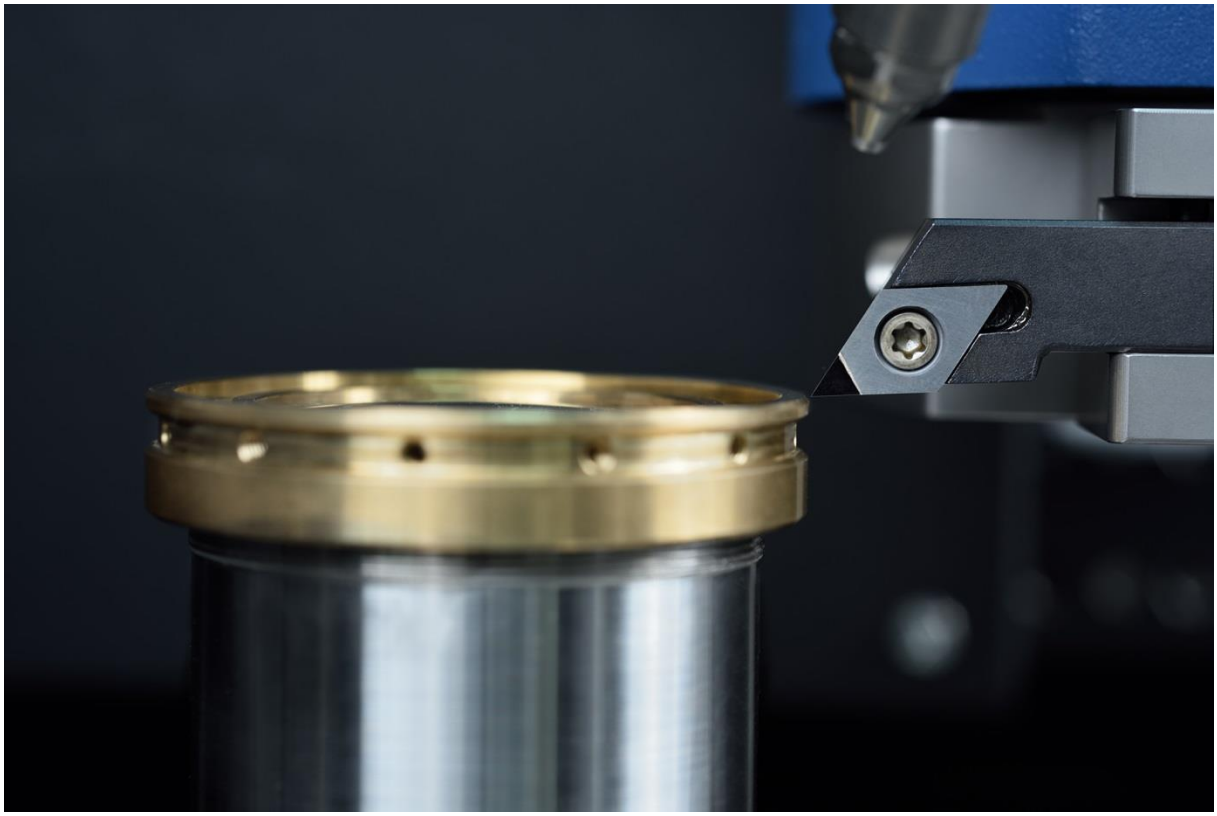
# Alignment turning: Fast production of high performance lens systems



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**The more precisely the distance of individual lenses can be set in a lens system and the better the respective optical axes of the individual lenses are aligned to each other, the more the imaging quality of the lens system can be increased. The following article describes the advantages that alignment turning offers over conventional methods in this process.**

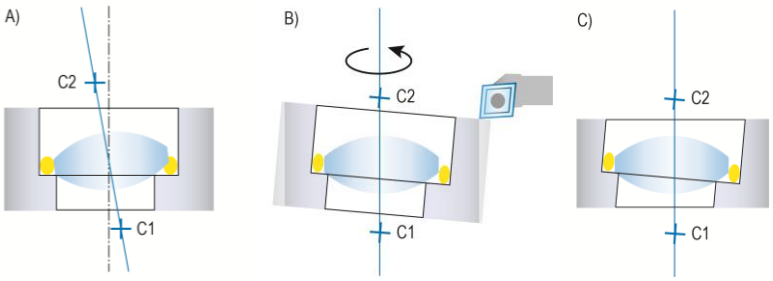
When calculating lens systems, the optical designer normally designs an ideal system, wherein the rotation axis and the optical axis of a lens system correspond; the drawings for lenses and mounts are also created accordingly.

During the manufacturing process of the lenses and mounts, inaccuracies occur due to clamping processes which are exhibited in the form of wedge errors. Likewise, the alignment process has significant influence on the final accuracy of the lens system. Inaccuracies in the mount, deviations in the center thickness of individual lenses and shrinking processes during the gluing process lead to the optical axis ultimately having small tilt and shift errors relative to the mount axis.

For the assembly of a complete lens system, multiple sub-mounts are then stacked. In doing so, it can be necessary to align some or all sub-mounts to a reference axis during the assembly process. If additional, still minor distance tolerances in the lenses must be equalized, so-called spacer rings are frequently used in this type of assembly to correct the actual center thickness or even manufacturing inaccuracies in the sub-mounts. This results

### What is alignment turning?

In alignment turning, lens mounts are processed so that the axes of symmetry of the mount correspond with the optical axis of the lens fastened in the mount.




A) Process of alignment turning: Optical axis of the lens is determined
B) Mount is aligned to the optical axis of the lens,
C) The edge of the mount is processed so that it is parallel to the optical axis

overall in a process which consists of many individual manual steps. In addition, each process step is encumbered by residual errors which quickly add up. These errors lead to a tilting of the "optical axis" and consequently to a deflection and inclination of the resulting image plane.

For many applications, the accuracy achievable today with modern production methods is sufficient. In the case of applications in measurement technology, microscopy and semiconductor technology, for example, one must endeavor to extensively minimize these residual errors, as well. For this reason, alignment turning represents an alternative to the described process for manufacturing high performance lens systems (see info box).

Using an alignment turning machine, manufactured mounted lenses can be combined without cumbersome adjustment, since both the tilt and the shift of the optical axis as well as the flange focal distance of the mounted lenses are set accurate to the micrometer.

Since the spring of 2015, the company Präzisionsoptik Gera (POG) has been working with the ATS 200 alignment turning machine from TRIOPTICS. The following section reports on the advantages POG's investment in the new technology promises and the production of a lens is described as an example.

For nearly 25 years, POG Präzisionsoptik Gera has developed and manufactured customer-specific lenses for the widest variety of applications from the aerospace, semiconductor, medical technology or mechanical engineering industries. In doing so, continually increasing customer requirements are met by continuously optimizing development and manufacturing processes. The lens manufacturing today takes place under clean room conditions and is equipped with modern measurement technology. The investment in the alignment turning technology was another important step for POG, who chose the ATS 200 alignment turning machine from TRIOPTICS.

The mounted lens is brought to its final dimensions by means of alignment turning in a single clamping operation. Lens centering, center thickness and mount are measured and remachined as applicable in this clamping.

## Mounting of high performance lens systems

Alignment turning is particularly well suited for the mounting of heavily customized high performance lens systems, such as high resolution lens systems for the semiconductor industry. These depend on a very precise correspondence of the optical axis with the mechanical axis – without tilt errors in the image plane at an image resolution of > 400 LP/mm. Moreover, a thermally stable position of the lenses must be guaranteed. Measurements are performed with high-resolution cameras at sub-pixel accuracy. Thanks to the high manufacturing accuracy of the alignment turning machine – the remaining alignment error after processing with the ATS 200 is less than 1 µm – the aforementioned requirements can be met.

Figure 1: ATS 200 by TRIOPTICS GmbH

In addition to the precise manufacturing of the centering of mounted lenses, the diameter and the flange dimensions of the mount as well as the center thickness of the lens are checked in the machine. These are important parameters for the assembly of the mounted lens, which is again significantly simplified by the custom-fit manufacturing of the flange dimension with respect to the measured lens thickness.

Alignment turning also provides a high degree of reproducibility of accuracy, in addition to manufacturing accuracy. POG utilizes a process in which the machine performs measurements independently at several points in the process in order to compensate for tool wear, for example. Processing accuracy – even when using carbide tools – is regularly under 2 µm. When using diamond tools, the accuracy can even be increased to less than 1 µm.

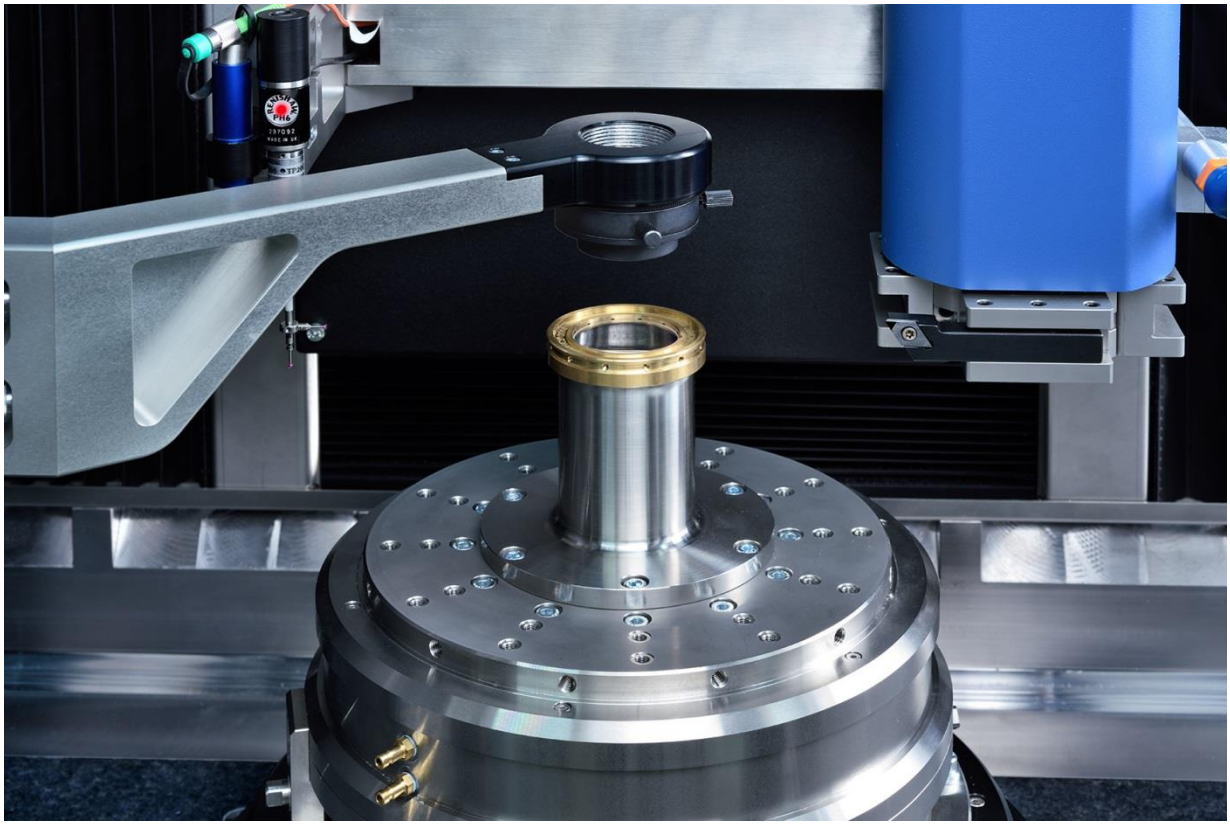


Figure 2: Measurement technology integrated in the alignment turning machine, here: integrated centering measurement technology on the basis of an OptiCentric system for determining the optical axis of the lens. Additional integrated measurement technology: Sensors for contact free distance measurement, low-coherence interferometer for determining the center thicknesses, probe for diameter determination. The entire measurement technology is integrated in the software

This high degree of reproducibility is immensely important in typical batch sizes of 20 to about 200 for the high performance lens systems and ensures uniformly high quality in the product life cycle of the lens system.

## Outlook

With the investment in an alignment turning machine with integrated measurement technology, new opportunities open up to the lens manufacturer in the production of high performance lens systems. Another application area of this technology is found in the production of mounted aspherical and infrared lenses.

## More Information

- www.pog.eu
- www.trioptics.com