Currently ITMO together with a consortium of industrial partners and TU Ilmenau are in the process to establish a laboratory for automated assembly of microscope lenses with unified design following the "Virtual Assembly Method". The laboratory will incorporate all necessary process steps like assembly, measurement and adjustment. Figure 5 shows the flow chart of the laboratory.

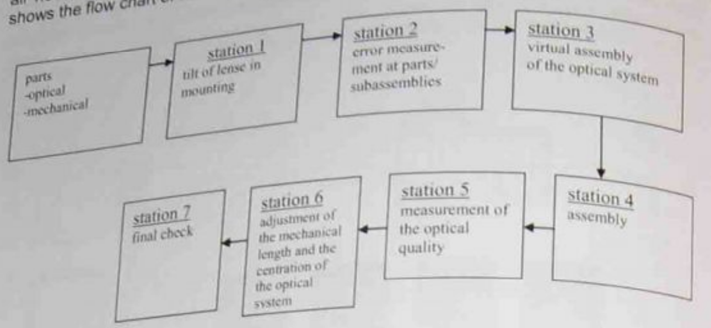

Figure 5 Flow chart of the laboratory

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Novel Precison Positioning System with Integrated Planar Guides

This paper presents the result of a joint project in the field of planar precision positioning systems. The main goal was the miniaturisation of a planar drive that has a travel range of ø 20 mm and a precision of 100 nm at all positions and is moreover capable to operate under high vacuum conditions. Several brainstorming workshops and inquests on the state of the art lead to a variety of new concepts and solutions. For the first prototype a sustainable integrated combination of standard subsystems (magnets and coils, optical measuring unit, 3 ball to plane guides) on a granite plate was chosen (see figure 1).

The precision of a planar electrodynamic drive heavily depends on the coils, the position measurement system and guidances.

The so called "Faltflex" technology enables the manufacturing of very flat coils based on lithographical structure definition. Such coils are basically folded polymer foils with conducting copper structures, which approving high ampacity.

In order to perform closed-loop controlled motions and positioning tasks, a high precision measuring grid and an optical detector were implemented in the z-plane of the actuator.

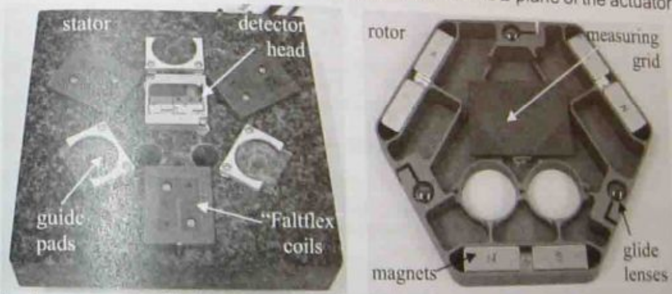

Fig. 1: open system (left - stator with guides and coils, right – rotor with magnets)

The key factor for slide bearing based systems is the material selection for the friction contact. Several material combinations consisting of Si, SiO_2, Si_3N_4, TiN, CrN, as well as several configurations of DLC, have been tested for this purpose. Wear tests in a micro-tribometer and subsequent analytical evaluations of the abrasion tracks led to DLC about an optical axis had the same lacks, as well as the image of the point laying on an axis of system. The condition it refers to as a condition of isoplanatics.

At purpose of admissions for manufacturing of optical details the designer "fulfils" real process of assembly of a microobjective when lacks of manufacturing of optical details are eliminated by change of a correctional air interval. In this case the collector manipulates two air intervals, one of which forward free working piece of a microobjective which limits of change are coordinated to its depth of the sharpness dependent on the working aperture. Changing the correctional air interval appointed by the designer, and making refocusing on object, the collector achieves minimal (on his subjective concept) a spherical aberration, and after check of passage of the working aperture considers, that the objective is ready.

For development of optical circuits of microobjectives it is possible to use components with beforehand known dimensional and aberrational properties.

In Russia the method of an estimation of quality of the image of systems of visual microscopy on character and size of distortion is used at diffraction on an aperture (the diffractive image of a point). At supervision in a plane of the image of a picture of Erie the information contained in a bright nucleus, the first dark minimum and in the second light maximum, enables to estimate size and character of the distortions brought by optical system. Quality of objectives is checked under the image of a point in the center of a field of vision and at edge. This method is recommended in shop certification. However, carrying out of such check needs the special equipment. For example, calculation and use of a special objective for the control is required. Optical calculation and a design of such objective it was offered.

As a result of the lead researches of face-to-face components the following conclusions are made:

1. The basic components, special aberrational correction for an opportunity of control, including with use of elements ASM, face-to-face components of microobjectives are demanding.
2. At calculation of frontal components important that condition Abbe was observed so-called, i.e. isoplanatics value should be minimal.
3. The original objective specially designed for the control of frontal components of microobjectives, has the following characteristics: V =-10x S =-8 mm A=0.45.

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Laboratory for automated assembly of microscope lenses

Section 5.1 Precision & Optical Engineering

This paper is about the concept of a laboratory for the automated assembly, verification and adjustment of barrelled microscope lenses under batch production conditions. Preparatory efforts are contributed by a new design of unified microscopic lenses as well as in the development of the "Virtual Assembly Method". The employment of this method to the assembly process of unified microscopic lenses opens new potential in cost reduction while keeping the optical quality at unchanged high level.

The automation of assembly processes of complex optomechanic and optoelectronic components and subassemblies is a challenging task since multiple error sources are influential to the commonly ambitious quality standards.

In particular deviations of the optical characteristics as well as geometrical variations of the optical and mechanical parts have a strong impact.

In many cases this problem can not be solved or adequately delimitated by tighter tolerances in order that the associated technological and economical effort is not affordable. This is in specific the case for the assembly of optical lenses. Very often adjustment is the only method to eliminate or compensate errors in an economical manner. The effort in adjustment can be reduced through the analysis of the particular single errors and their influence to the overall system under use of the "Virtual Assembly Method". In specific the automated assembly of microscope lenses is highly complicated since they are diffraction limited multiple-unit optical chains with highest demands to the optical quality. Following Abbe the optical resolution ε is determined by the light wavelength λ and the aperture A ($\varepsilon = \lambda / (2A)$).Figure 1 shows the layout of a microscope lens of a novel unified design with a high percentage of unified elements.

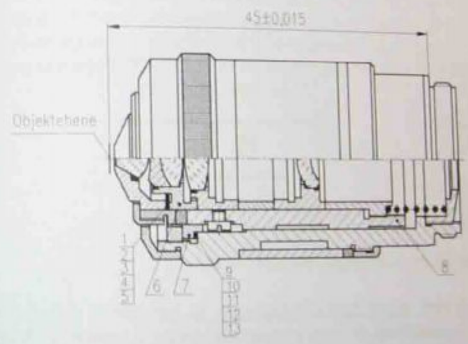


Figure 1 Layout of a microscope lens of a unified design

The correction of the spherical aberration of all elements caused by deviations in the vertex thickness (Δd), the air gap (Δt) and the refractive index of refraction (Δn_e), radius(ΔR) is done up to now manually by iterative variation of the number of spacers (Position 1-5). That results in a time and labour intensive mounting and dismounting process. Applying the "Virtual Assembly Method" the tuning length for minimized spherical aberration can be calculated in a mathematical model hence the assembly can be done in one step. The mentioned critical deviations of all elements need to be measured beforehand since they are required as an input in the mathematical model (Figure 2).

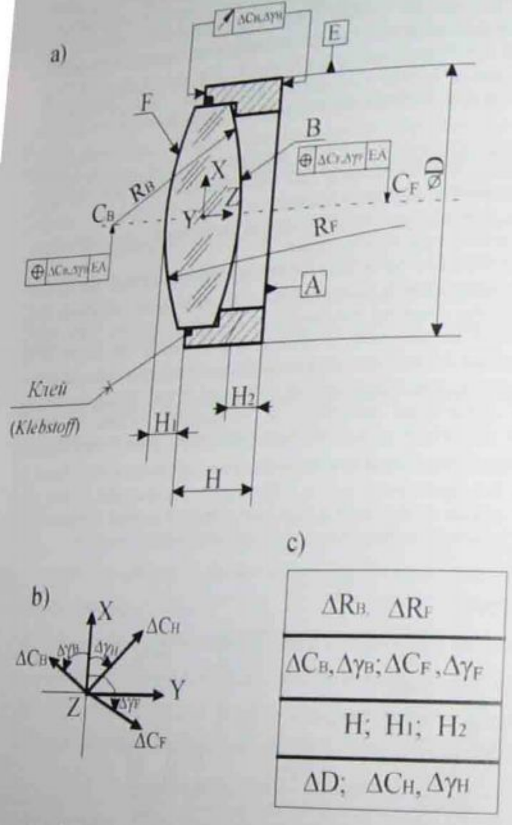
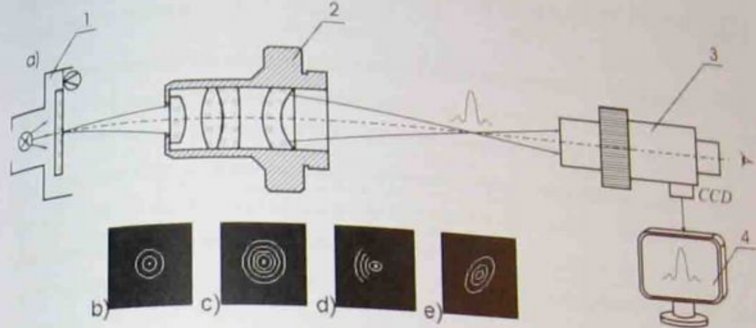


Figure 2 Critical deviations at a single mounted lens

The residual decentration of all optical subgroups to the barrel cylinder (#8, Figure 1) generates coma that classically derives compensation by a lateral shift of subassembly #6 after completion of the mounting process. This lateral movement can be done through a borehole in cylinder #8. The adjustment process can be avoided in a similar way as described for the spherical aberration. It needs the preliminary determination of the decentration of all optical surfaces and utilisation of the "Virtual Assembly Method". The mathematical model used for this purpose allows the determination of the mounting orientation of each subgroup individually. Figure 2b shows the parameters to be measured. A precondition for the utilisation of the method is a tolerance calculation of the whole optical system that guaranties that the residual errors are small enough. The final check of the optical quality is done by the diffractive image of the lens under use of a CCD- matrix (Figure 3)

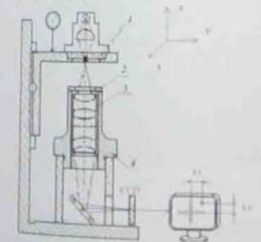


Legend: 1 illuminated pinhole, 2 microscope lens, 3 frame grabber, 4 computer

Figure 3 a) Scheme of the check setup b)-e) typical diffractive images

Information's about the optical quality can be derived from the analysis of the Point Spread Function (PSF). Types and quantities of the residual optical aberrations can be identified. Is the optical quality in accordance with the expectation the next step can be taken.

The mechanical standard length (distance in-between the object plane and the mounting surface (A, Figure 1) and the centration of the optical system needs to be adjusted. In difference to the common way of the correction by machining the mounting surface to the dedicated length in centered state the new design allows the adjustment by a linear shift(given by a spacer #9- #13) and rotation of the cylinder #8.
Figure 4 shows the principle of a setup to measure standardised mechanical length and centration



Legend: 1 illuminated reticle, 2-4 microscope lens

Figure 4 Principle of the measuring set up