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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.

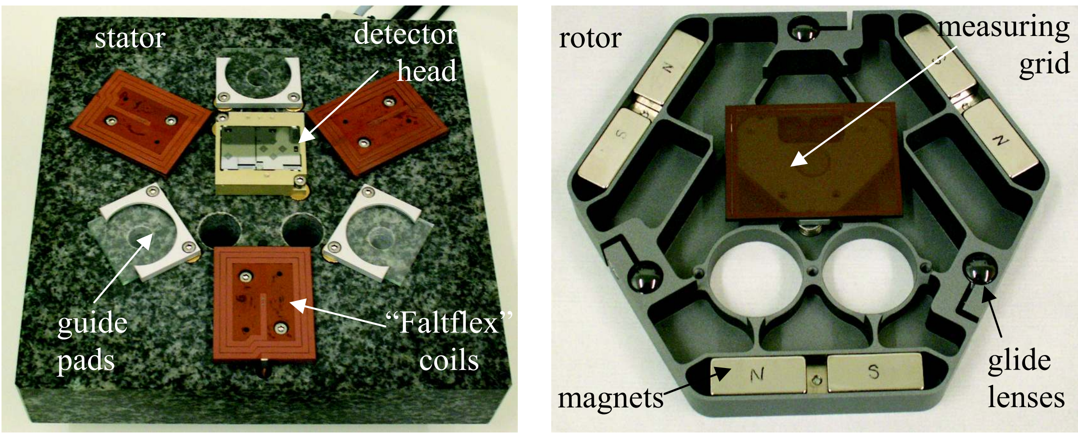

Fig. 1: open system (left - stator with guides and coils, right – rotor with magnets)

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 coated glass lenses and DLC-coated glass plates as a counterpart.

The stick-slip effect for most other combinations was dominating the system behaviour at low velocities, which made a sub-micrometer positioning almost impossible. A running-in-period is necessary to form a homogenous mechanical interface between the glide lenses and the guide pads before normal operation. This also reduces the residual stick slip effect.

The guiding system has been modular integrated (mechanical clamping of the glide lenses and guide pads) to allow a fast material exchange. Continuous mode experiments (see figure 2) where the rotor was moved on the guides in circular paths lasted about 2 days till the abrasion on the guide pads induced fatal malfunction. A current tracing system during operation was used to derive real time information about the wear and friction parameters. The overall abrasion for defect free gliding pairs is in the range of 20 - 50 nm/hour and thus qualified to be suitable for special applications (e.g. in high vacuum systems).

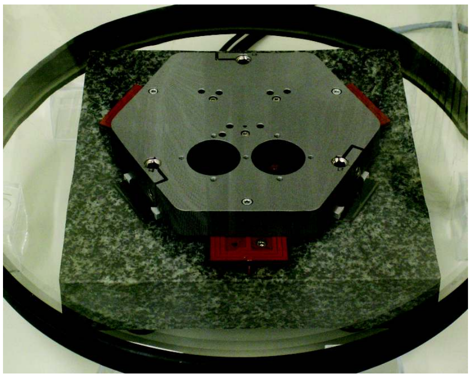

Fig. 2: assembled precision positioning system under a glass hood

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