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Customized ion beam technologies for ultra-precision surface machining of optical devices

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Ion beam figuring (IBF) is an established method in ultra-precision surface finishing. For the fabrication of modern optical devices novel processing routes are needed to fulfill the demands for the diversity and increased complexity of surface shapes, the choice of material, and the size range of optical components. A scalable and most flexible technology meeting those requirements is the deterministic ion beam figuring technique, i.e. a small-sized ion beam tool is scanned along the optical surface to attain a customized local surface correction. The contribution gives an overview of the technology covering following aspects:

1. Metal mirrors are most interesting for short wave-length applications. However, because of alloy matrix irregularities the ultra-precision finishing is challenging. Promising potential was found in reactive ion beam machining. For aluminium surfaces the usage of O_2 or N_2 process gas results in the in situ formation of a defined etch front passivating the matrix irregularities during the ion beam processing. Machining depths up to 1 micron are achievable without surface degradation.
2. For compact and integrated optical systems optics with an aspherical shape or even freeform surfaces are required. Deterministic ion beam machining allows most flexible shape processing and thus provides a sophisticated technology for figure error correction of those individually designed optics. As an example, the machining of a deep paraboloidal mirror is focused. A processing geometry with fast sample rotation is chosen to correct the radial concentric figure error by a set of discrete ring removal steps.
3. Optical devices cover a broad size range depending on the target application, e.g. meter-scale astro mirrors, millimeter-scale laser components, and micrometer-scaled integrated imaging elements. In principle, deterministic ion beam processing is fully scalable. Differently sized ion beam tools for figuring of diversely scaled surfaces are presented.

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