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PII: S0141-6359(16)30151-9
DOI: http://dx.doi.org/doi:10.1016/j.precisioneng.2017.01.004
Reference: PRE 6512

To appear in: *Precision Engineering*

Received date: 12-8-2016
Revised date: 23-12-2016
Accepted date: 14-1-2017

Please cite this article as: Chkhalo NI, Kaskov IA, Malyshev IV, Mikhaylenko MS, Pestov AE, Polkovnikov VN, Salashchenko NN, Toropov MN, Zabrodin I.G.High-performance facility and techniques for high-precision machining of optical components by ion beams.*Precision Engineering* http://dx.doi.org/10.1016/j.precisioneng.2017.01.004

High-performance facility and techniques for high-precision machining of optical components by ion beams

The paper describes a high-performance facility for ion beam processing of the surface of optical elements. The facility is equipped with three technological ion sources, which allow working with inert or reactive gases, and a five-axis goniometer. Two sources (KLAN-103M and KLAN-163M) have a wide-aperture quasi-parallel ion beam and a third ion source with a focused ion beam (width of the output beam is Ø1–15 mm by changing the diaphragm). For a focusing ion source an optimal diaphragm material (sapphire) and the Ar energy range (less than 400 eV), which minimizes deposition on the surface of the workpiece of material sputtered from the edge of the diaphragm, are found. The concept of a movable workpiece has allowed the realization within one vacuum chamber of three methods of ion beam surface treatment: aspherization, local shape errors correction and ion polishing. A detailed description of all the surface treatment methods is given. An algorithm for selecting the ion beam diameter and scanning steps for the local shape errors correction depending on the lateral dimension of the surface errors is proposed. The facility makes it possible to produce an optical surface of any complex (convex/concave) shape, including higher-order aspheres with an asymmetrical profile and a diameter of up to 300 mm, with a subnanometer precision of the surface shape and the effective roughness in the range of spatial frequencies $q \in [2.5 \cdot 10^{-2}\text{-}6.0 \cdot 10^{1}$ $\mu m^{-1}]$ down to σ_{eff}=0.14 nm.