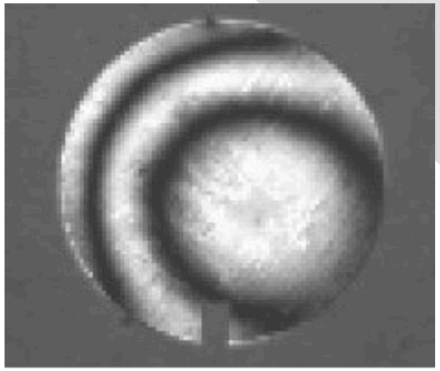
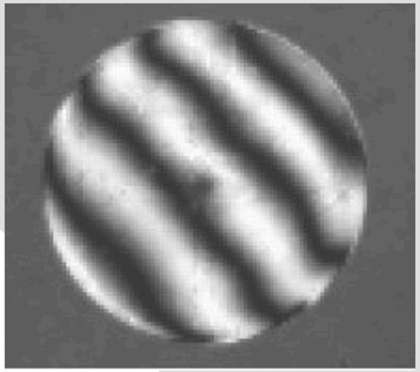
INTERFEROGRAMS OF OPTICAL GLASS SURFACE BEFORE (A) AND AFTER (B) MAGNETIC-ABRASIVE MACHINING



a) PV = 158 nm, Ra = 20 nm



b) PV = 30 nm, Ra = 1.4 nm

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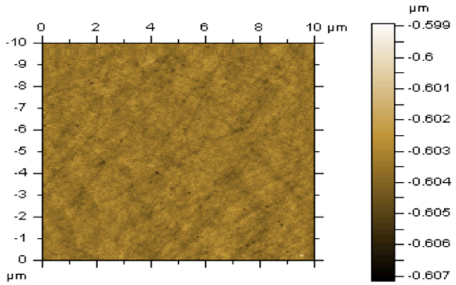
MAGNETIC-ABRASIVE MACHINING

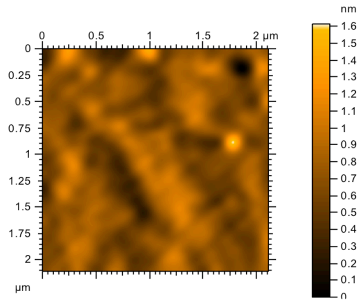
Before MAM Sa = 2.72 A



ISO 25178
Height Parameters

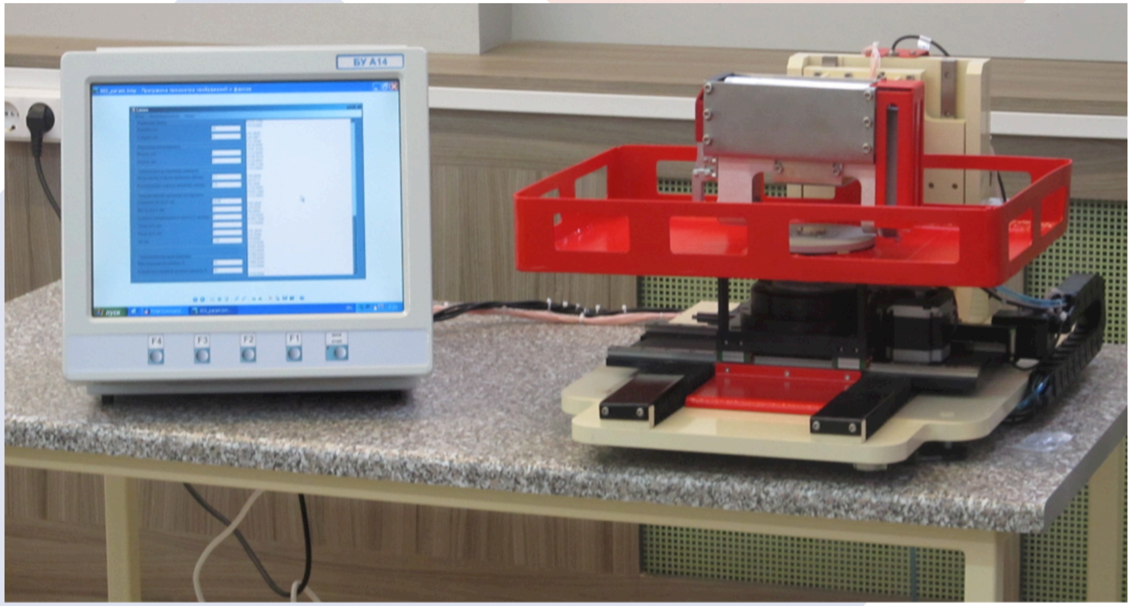
Sq	0.000369 µm
Ssk	-0.256
Sku	4.04
Sp	0.00458 µm
Sv	0.00366 µm
Sz	0.00824 µm
Sa	0.000272 µm

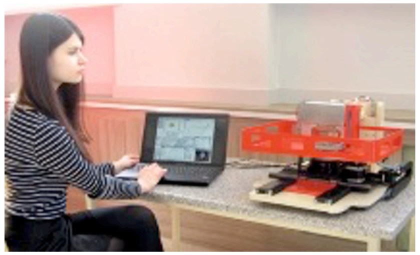
After MAM Sa = 1.42 A



ISO 25178
Height Parameters

Sq	0.189 nm
Ssk	0.137
Sku	3.76
Sp	1.13 nm
Sv	0.735 nm
Sz	1.87 nm
Sa	0.142 nm





System A14 in the autonomous clean area

Analogue (Q22-XE)

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SUPERFINE POLISHING OF PARTS OF OPTICS, LASERS AND ELECTRONICS

SUPERFINE POLISHING OF PARTS FOR OPTICS, LASERS AND ELECTRONICS

Problem relevance

The problem of surfacing with nanoscale relief (Ra < 1 nm) and near-surface layers forming with a minimal amount of structural defects is of the most immediate interest to the heavy duty details of the optical, laser and electronic equipment. Surface-finishing improvement affects:

- the optical systems resolution and microoptics performance capabilities;
- progress in the development of powerful and compact lasers, scope and effectiveness of their application in various fields;
- reduced dimensions of elements and devices for micro- and nanoelectronics.

The industry circumstances

The traditional finishing technology for precision surfaces of optical lenses and single crystals – optically active elements of laser devices and wafers for integrated circuits is realized with grinding by wheels with fixed abrasive grains and with subsequent polishing by pastes or suspensions. The grinding wheels application provides hard contact with the treated surface. There are high local temperature (up to 2000°C) and high normal pressure values in the contact zone during processing. Under these conditions the surface layer is formed with a large number of structural defects. The layer depth is 25...75 µm. This layer is removed later by a number of polishing operations using free (unfixed) abrasive grains.

Currently the single crystal wafer and optical glasses are treated by the traditional method with the grinding powder – polishing pads and diamond pastes. This technology is time-consuming and very expensive. The polishing costs compose a considerate share (30% and over) of the wafer-plate cost. The best technology modes provide surface relief with roughness height of 2...5 nm. Finishing methods of chemical and mechanical surface treatment are also widely used in modern production (such as chemical etching, chemical-mechanical polishing, etc.). However, these methods are time-consuming and have limited technological capabilities besides their use is associated with the environmental and economic problems of usage and recycling of large amounts of chemically aggressive acids and alkalis.

Today there are only a few large companies worldwide with scientific and technical potential and sufficient production capacity which are able to provide mass-producting high-precision equipment for finishing precision surfaces of parts for optics, electronics and laser optics: «Satisloh» (Germany), «Optotech» (Germany), «Speed Fam» (the USA), «Lapmaster» (England), «Fujikoshi» (Japan) and others.

In recent years, magnetorheological finishing (MRF) technologies have widely spread at finish machining of optics and lasers elements. The MRF principles were developed in Belarus but the development has not been brought to the industrial application for lack of financial resources. The MRF technology was further developed in the USA with more than $10 million investments. Nowadays the QED Company (USA) offers the MRF technology to the world market. The QED has a monopoly on the production of equipment and assistive technology environments. This technology provides the surface roughness in the range of Ra = 0.2...0.3 nm and shape accuracy of 6...10 nm.

However, the application of MRF technology is highly complicated because of unstable and nondurable magnetorheological suspension used as the polishing medium. In addition, the cost of QED installation and related monitoring equipment exceeds 400 thousand USD. The technological media-suspensions cost is about 500 USD per 1 liter. These costs are clearly overestimated and unpurchasable for the majority of potential consumers. The MRF technology features of maintenance and economic factors significantly limit the scope of its industrial application.

The new solution – superfine Magnetic-Abrasive Machining

Magnetic-Abrasive Machining method. Description, features and benefits

The Magnetic-Abrasive Machining (MAM) method is performed with ferro-abrasive powder-tool that is compressed under the magnetic field influence, nestles against the treated surface and polishes it.

By MAM method implementation the processes of sub-microabrasion, elasto-plastic metal shift and surface smoothing are dominating, in contrast to traditional abrasive technologies. The temperature in the contact zone of ferro-abrasive grain and the workpiece is less than 150°C, surface defects usual for abrasion are not formed. The applied pulsed magnetic field is very important at MAM. It facilitates the action of magnetoplastic, magnetoelectric and magnetostrictive effects in the workpiece surface layer. Under their influence the weakly-fixed structural defects (dislocations, disclinations, rotations, etc.), formed during the preceding treatment, are set in motion (like Brownian). A significant part of the moving defects comes to the surface and the "soft brush" formed by ferro-abrasive powder fabricates surface nanorelief with minimal roughness and surface layer with a minimum of structural defects – potential sources of material failure.

There are more details about the MAM method on our website www.polimag.eu.

The MAM method is superior to the known analogues in technological opportunities, economic and environmental parameters.

Equipment for MAM

The software-controlled system A09 was developed for the single-piece **MAM of flat, spherical and aspherical surfaces** of the parts with a diameter of 15...80 mm **in order to improve the macrogeometry and to reduce the surface roughness**. MAM parameters are entered into the Computer-Numeric Control according to the initial (mechanically polished) surface interferogram. The MAM process is accomplished by automatically surface scanning with the flexible magnetic-abrasive tool; the material removal occurs selectively on the surface prominent parts. For example, the MAM of the flat optical glass plate with diameter of 28 mm provided the macrogeometry parameter PV reduction from 158 nm to 30 nm and the reduction of Ra from 20 nm to 1.4 nm in 6 minutes only.

A09 technical specifications:

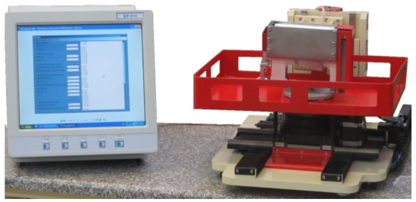
- polished details diameter 20…100 mm;
- polished surface nanorelief parameter Ra < 1.5A or better;
- polishing duration 2…15 min;
- power consumption 1.5 kW;
- installation overall dimensions L x B x H, mm 900 x 500 x 500;
- installation weight 80 kg.

This year (2015) we are going to complete the implementation of:

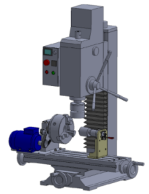
- the system A14 exceeding in the technological capabilities the system A09 and providing polishing of parts with dimensions from 20x20 up to 200x200 mm and with Ra <1 nm;
- systems M14 and M08 for the single-piece and group parts MAP with a diameter up to 200 mm.

The above given performance and quality specifications of the MAP of parts for optical, laser and electronic equipment are not limited and will be essentially improved.

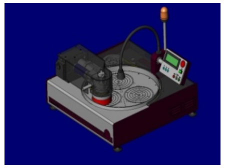
A09



A14



M14



M08