Subnanometer treatment of optic components

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Magnetorheological polishing (MRP) method was developed at HMTI NASB for finishing of optical glass [1]. MRP consists in immersing of treated surface into magnetorheological fluid (MF) (based on ferromagnetic particles), formation of working zone by applying an external magnetic field and moving of working zone on special trajectory. MF under external magnetic field changes dramatically its rheological properties and turns into a viscoplastic medium, which allows polish nonmagnetic materials. In fact, MF acts as a polishing tool that is well adapted to the shape of treated surface. MRP provides formation of spherical, aspherical and flat surfaces [2] with $\lambda/40$ - $\lambda/100$ form accuracy. Currently MRP is effectively used in the manufacture of precise optical components, large astronomical mirrors, laser crystals (including water-soluble KDP) and components of microelectronic devices with dimensions up 5 to 2500 mm.

MRP allows to remove subnanolayers of the material without any destructive deformation on treated surface. Therefore the removal process of the material can be described as nanowearing effect. The essential difference of MRP from conventional methods is that the material is separated from the surface and continuously is carried away from the friction (working) zone by flow of MF, which also ensures efficient withdrawal of heat from contact area that minimize the temperature effect on the treated material. This type of surface treatment can help to remove the defective surface micro- and nanolayers and provides increasing of radiation resistance of optical component in 5-10 times.

Analysis of surface roughness by atomic force microscopy (AFM NT206 “MicroTestMashines”, Probe NSC11 “MikroMaschCo”, Scan area 30x30 μm, Contact mode) for various materials after MRP treatment showed the following results: Optical Glass K8 - Rq = 0.6 nm, Silicon - 0.8 nm, Polycrystalline ZnS - 0.8 nm, BaF_2 - 0.9 nm, LiF - 1.2 nm, Pyroceram SB-115 - 0.22 nm. It is established that the surface roughness of optic component after magnetorheological polishing has nano- and subnano level and quality of surface extremely depends on morphological structure of treated material.

1. *Golini D., Kordonski W.I., Dumas P., Hogan S.* Magnetorheological Finishing in Commercial Precision Optics Manufacturing// SPIE Proc.-1999.-**3782**.-P. 80-91.
2. *Griesmann U., Wang Q., Tricard M., Dumas P., Hill C.* Manufacture and Metrology of 300 mm Silicon Wafers with Ultra-Low Thickness Variations / AIP Conference Proceedings.-2007.-**931**.-P.105–110.