Magnetorheological finishing (MRF) is a deterministic method for producing complex optics with figure accuracy <50 nm and surface roughness <1 nm.
Outline

- History. Introduction.
- Advantages of magnetorheological polishing
- Application, HMTI expertise
- General aim of R&D project
History

1987 – A magnetorheological fluid was used for the first time in joint work of the Heat and Mass Transfer Institute with the Institute of Optical machine – Tool Manufacture.

1988 - A prototype machine for magnetorheological finishing was awarded a silver medal of the All-Union Exhibition of the Achievements of the National Economy of USSR.

1990 - Some HMTI researchers moved from USSR to USA and established QED company that focused in magnetorheological finishing.
The technology of magnetorheological finishing (MRF) – a high-quality technique of processing optical and semiconductor parts. It is based on the alteration of the rheological properties of a magnetorheological polishing fluid (MR fluid) on exposure to a magnetic field. In a magnetic field an MR fluid becomes a viscoelastic medium acting as a polishing material.
Magnetorheological Fluid

Basic components

- Abrasive particles
- Liquid base
- Magnetic particles

MR fluid
Formation of polishing zone after the contact of MR fluid with the surface of the part on exposure to gradient magnetic field
MRF polishing machines produced at Heat and Mass Transfer Institute
MR Polishing Module

MR working tool with its position above the part processed

MR working tool configuration with its position above the part to be polished below
Software

- Program monitoring the shaping of the part
- **Software controlling part motion**
- Program controlling MR fluid stability
- Simulation regimes of MR polishing

Spiral trajectory in the case of axysymmetrical rotation of the part

Raster trajectory. The part does not rotate
Diagnostics

Examples of the surface quality control by AFM
3D Optical Profiler Diagnostic

3D Optical Profiler MicroXAM-800 (KLA-Tencor, USA)
Complex analysis of Roughness and Waviness parameters

Surface of laser component from Beta-Barium Borate (β-BaB2O4 or BBO) after magnetorheological polishing  
\[ Ra = 0.202 \, \text{nm} \]
Advantages of MRF technology

1. Shape of the surface of the parts processed: spherical (convex, concave); aspherical (convex, concave); plane

2. Size of the parts from 3 mm to 2 meter (and more)

3. Error in the shape of the surface typically $\lambda/100$ and lower

4. Process with high level of automation with predictable quality

5. Wide range of materials, including super hard ceramics, non-magnetic metals and composites.

6. Open market to Russia, China, India, Brazil and etc.
Application

Biomedicine and Fine machinery
- Artificial joints, Medical tools, Precision ways, Valves, Tubes

Semiconductor manufacturing
- Wafers 30-300 mm (Si, GaAs, Ge). Thin Si layers on insulator (20-50 nm).

Optic and Laser industry
- Spherical, aspherical, plane optic components up 5 mm to 2 miter; optic ceramics, laser crystals.

Space and Aircraft
- Astronomic mirrors, Space segment mirrors, Aircraft cap, Space (Aircraft) optic and laser equipment

Cost of component
HMTI expertise in MRF

- Technology (patented)
- Equipment (patented)
- Software
- Fluid (patented)
- Diagnostic universal
General aim of the project is to create **Series of MRF machines (5 machines)** for covering large share of market of modern and unique components production with part dimensions up 3 mm to 2m.
Thank you for attention!