Heat and Mass Transfer Institute

Smart Polishing Technology

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

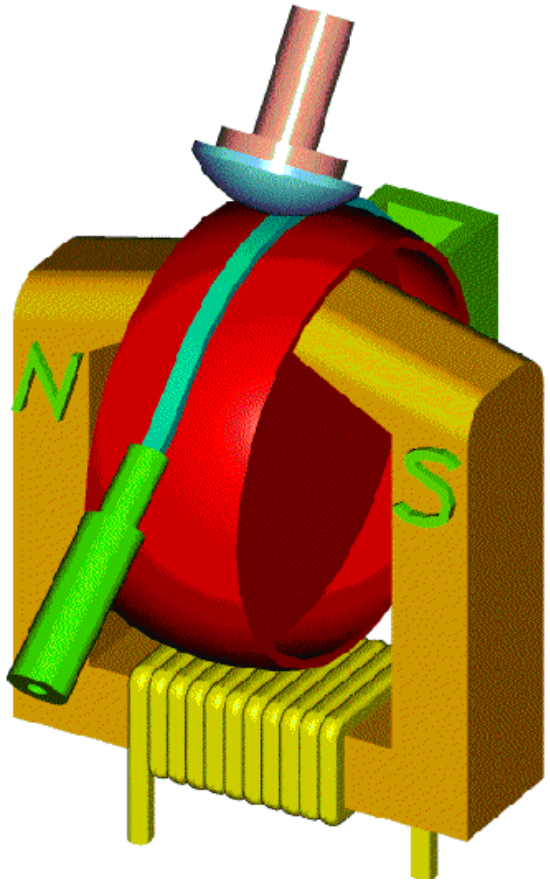
History

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.

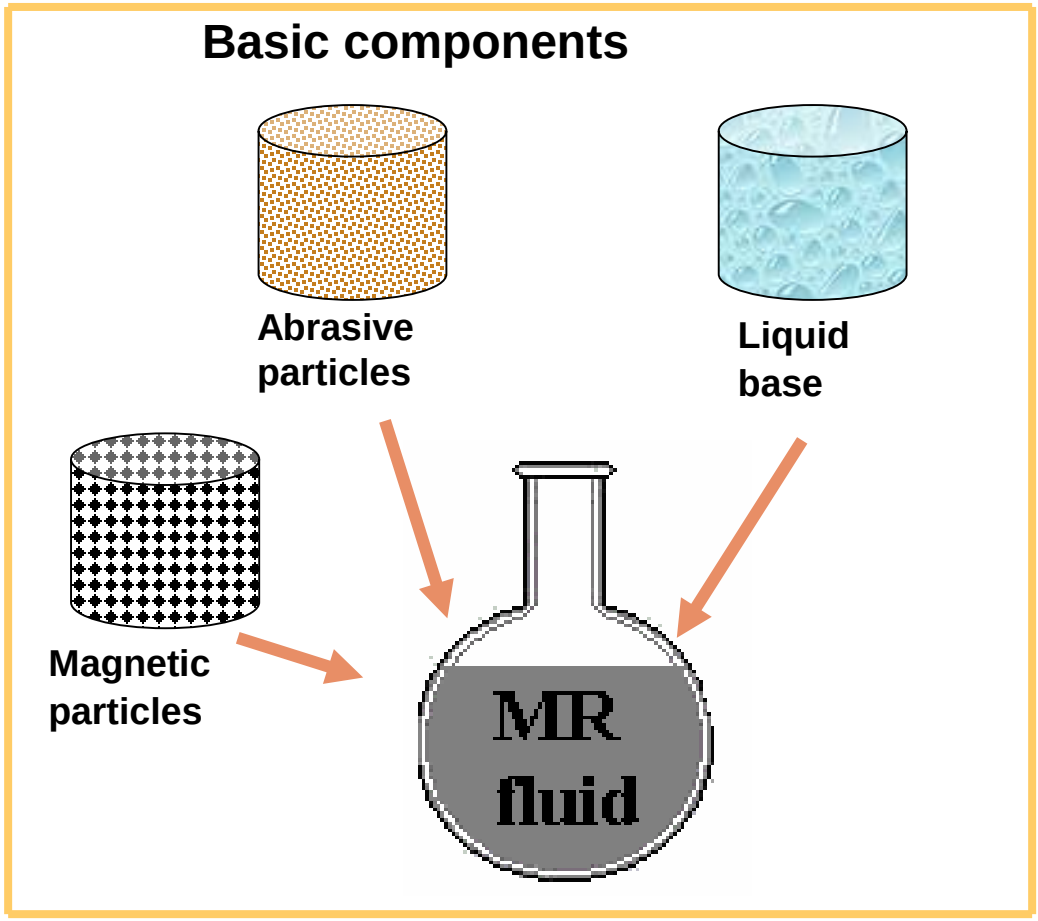
1990 - Some HMTI researchers moved from USSR to USA and established QED company that focused in magnetorheological finishing

Introduction

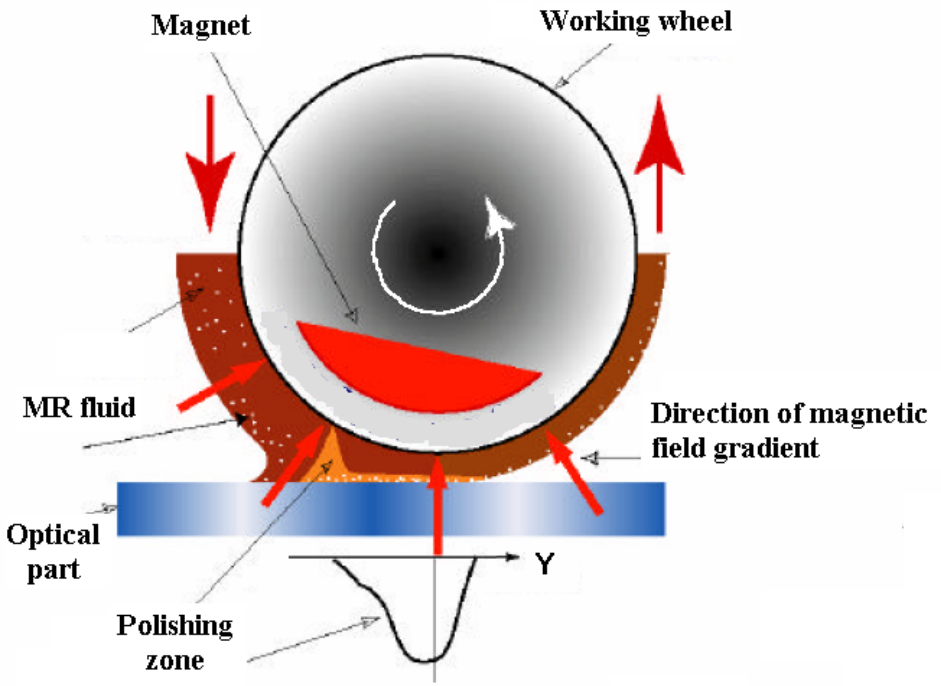


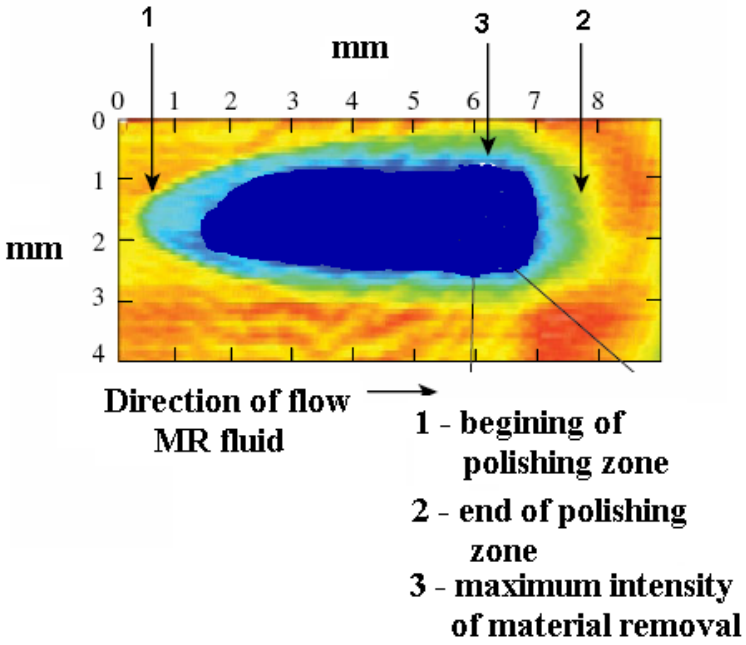
The technology of magnetorheological finishing (MRF) – a high-quality technique of processing optical and semiconductor parts. It is based on the alteration of the rheological properties of a magnetorheological polishing fluid (MR fluid) on exposure to a magnetic field. In a magnetic field an MR fluid becomes a viscoelastic medium acting as a polishing material.

Magnetorheological Fluid



MRF Technology



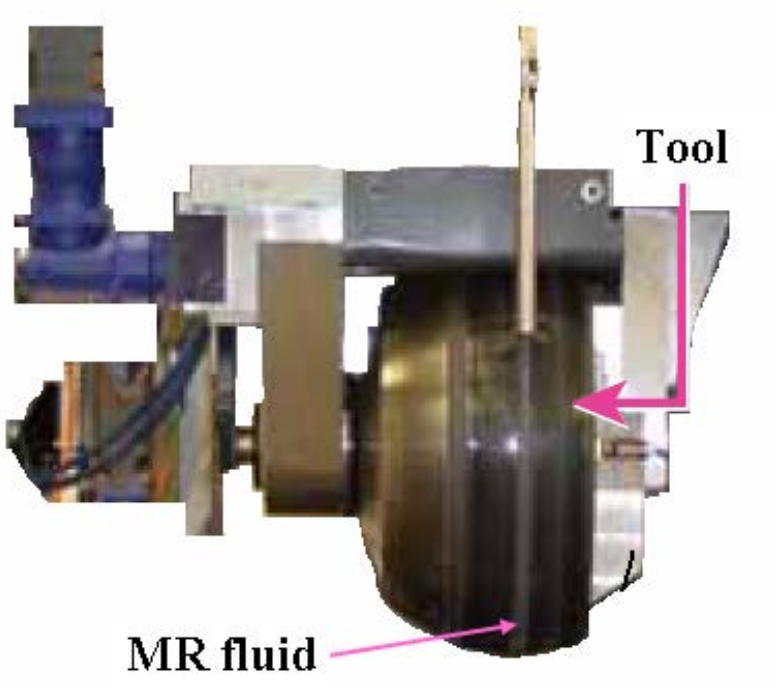


Formation of polishing zone after the contact of MR fluid with the surface of the part on exposure to gradient magnetic field

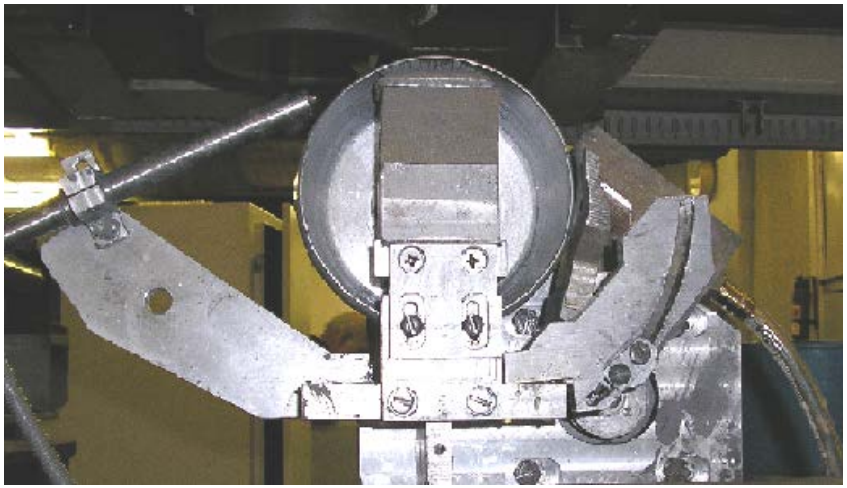
MRF Equipment

MRF polishing machines produced at Heat and Mass Transfer Institute

MR Polishing Module



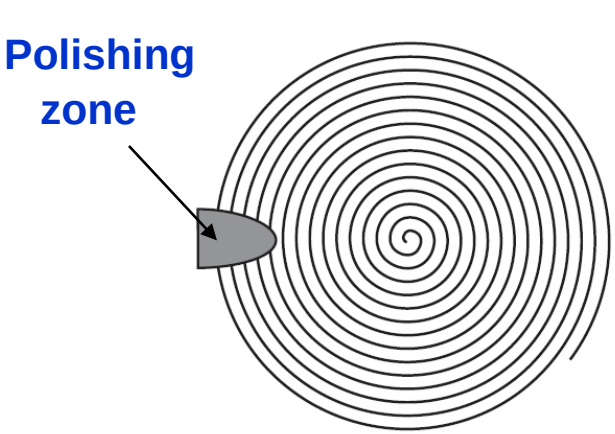
MR working tool with its position above the part processed



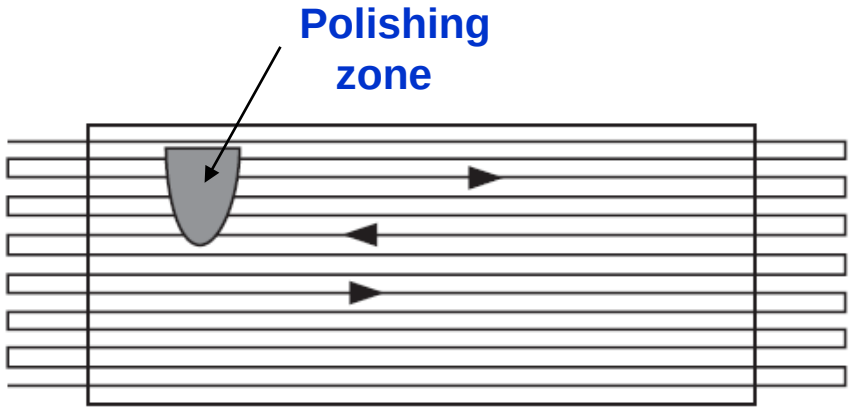
MR working tool configuration with its position above the part to be polished below

Software

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



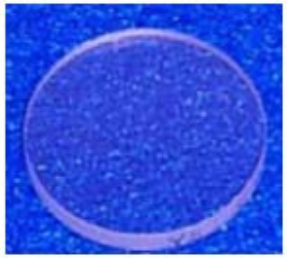
Spiral trajectory in the case axysymmetrical rotation of the part



Raster trajectory. The part does not rotate

Diagnostics

BaF2



Rq- 0,9 nm

Optical glass K8

Rq- 0,6 nm

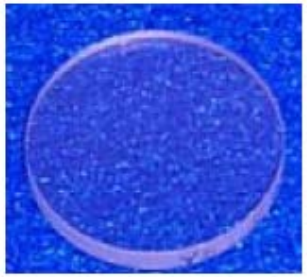
Polycrystalline ZnS

Rq - 0,8 nm

Sitall

Rq - 0,22 nm

LiF

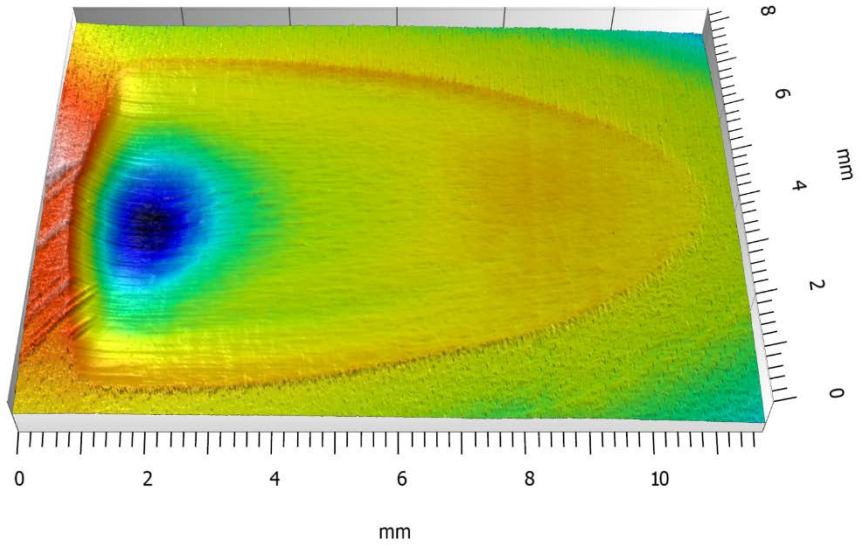


Rq -1,2 nm

Examples of the surface quality control by AFM

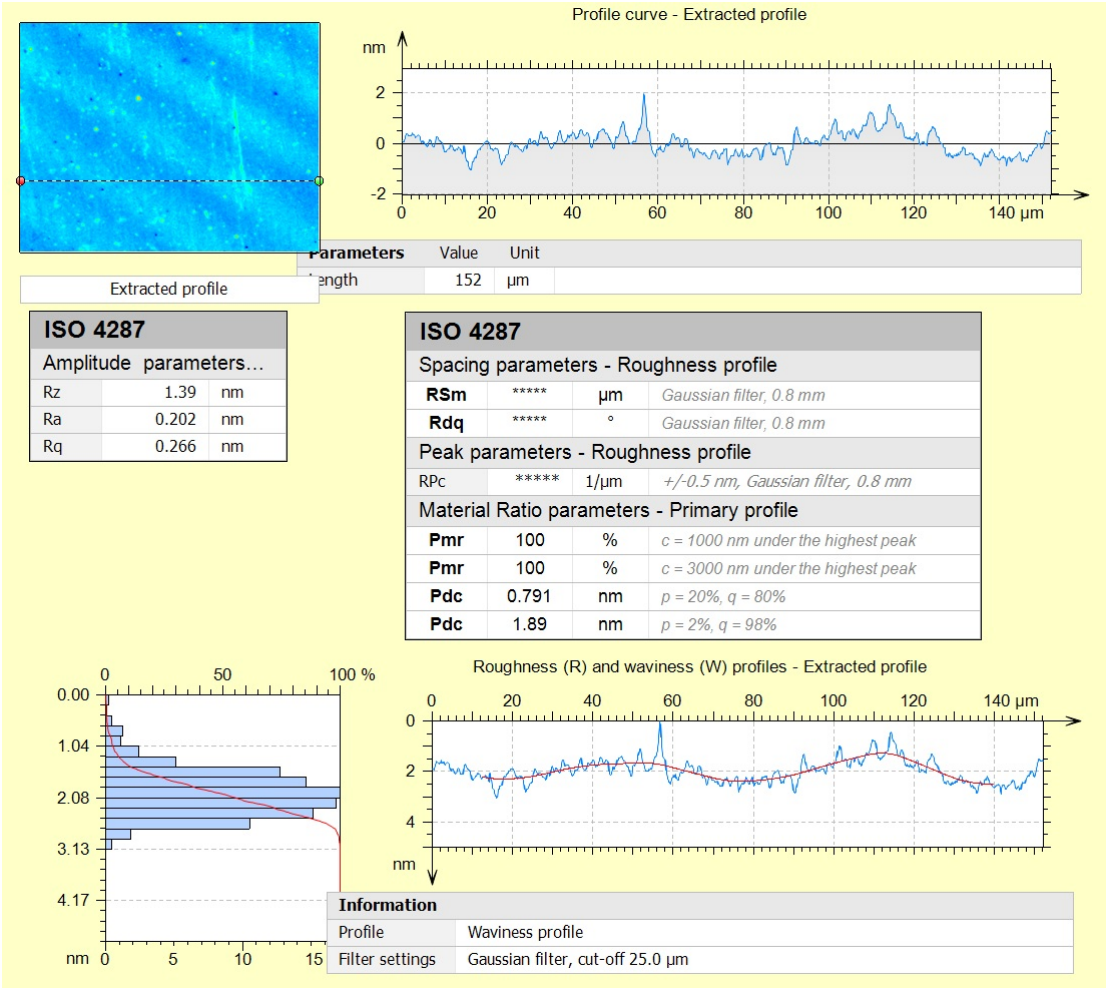
3D Optical Profiler Diagnostic

3D Optical Profiler MicroXAM-800 (KLA-Tencor, USA)



3D view of polishing zone

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 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 λ/100 and lower

4. Process with high level of automation with predictable quality

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

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

Application

Space and Aircraft

Optic and Laser industry

Semiconductor manufacturing

Biomedicine and Fine machinery

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

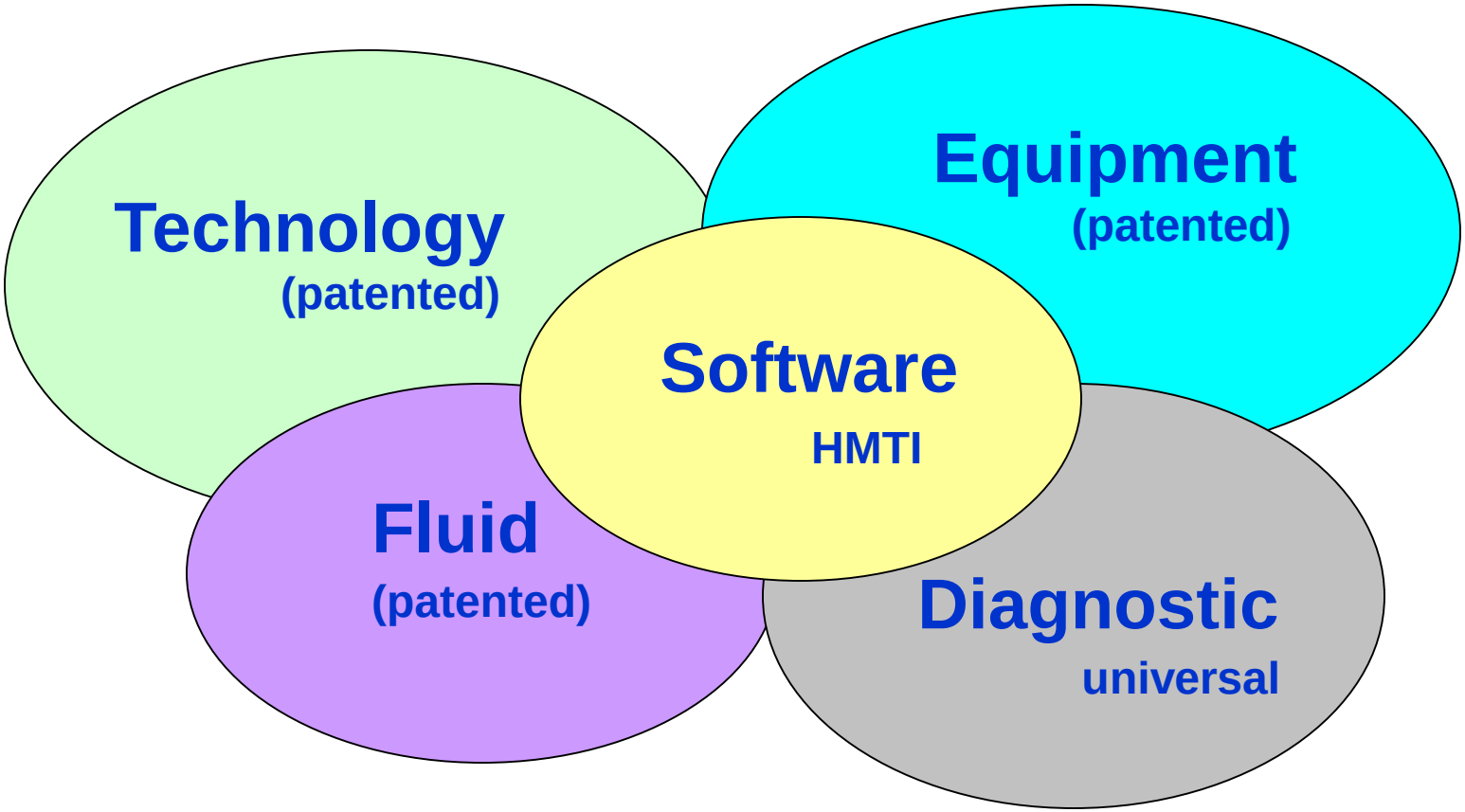
Spherical, aspherical, plane optic components up 5 mm to 2 miter;
optic ceramics,
laser crystals.

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

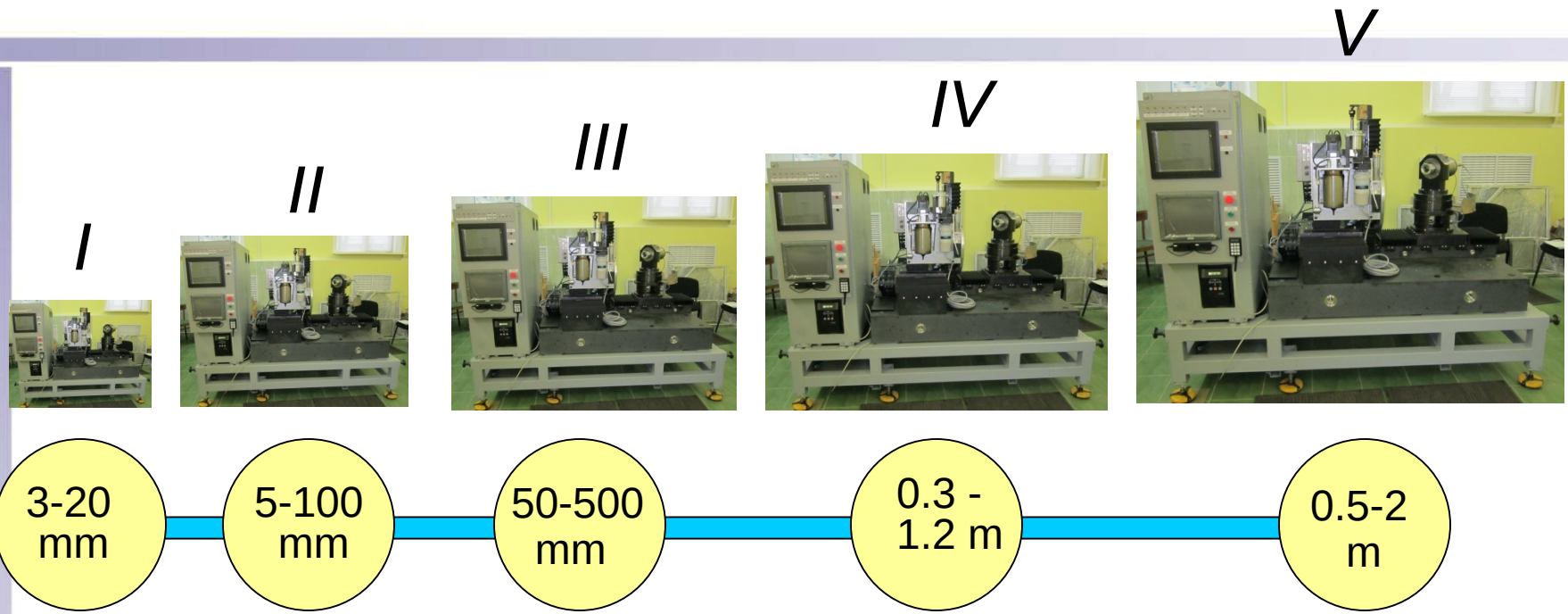
Artificial joints,
Medical tools,
Precision ways,
Valves, Tubes

Cost of component

HMTI expertise in MRF



General aim of R&D project



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!