Achievement of technologies and testing methods for resilient mirrors under high power laser pulse, suitable for CETAL and ELI infrastructures / REMI

Stage 1 / Activity 1
(Work-package 1)

Study regarding the large dimension optical surfaces processing

The final objective of this project is to acquire the capabilities needed to process precision optical surfaces that would be suitable for use in optical systems that contain high power 1PW pulse lasers like the CETAL or ELI infrastructures.

In order to achieve this, we will have to successfully finalize several technological intermediary objectives.

FLAT SURFACES

At the current time, the precision optical processing of pre-shaped glass in Pro Optica is made by semi-automatic or manual grinding and fine grinding[1] after which the optical flats are placed on a precision lapping machine[2] for polishing to a roughness of under 2nm.

The target specifications for this projects optical flats are a good flatness (the aim being λ/20 nm) and a surface roughness of under 2nm.

In work-package 1 we will focus on the flat surface processing part of the projects. In this regard, we will start with small flat optical components and condition the Lapmaster's[3] pitch surface in order to achieve and maintain a good flatness. These will be blocked on contact on a blocking piece in order to insure that the flatness resulted is the real flatness of the machine.

While the small pieces are processed on the Lapmaster and the machine's flatness is constantly corrected, we will work on the large diameter mirrors that are the primary objective of this project.

The large mirrors will be made from fused silica which has a better thermal coefficient than other optical glass, this insures that the glass will not have to be acclimatized for as long as other glasses before use or measurement and will not be impacted as much by temperature fluctuations in the working environment.

Also, fused silica is a much harder type of glass which insured durability and a better scratch-dig tolerance at the optical surface.

During the polishing on the Lapmaster, the flatness of the machines pitch is kept by constantly correcting it with the corrector that is installed on one arm of the machine.

This corrector is a large weighted optical flat on which more weight can be added or taken in order to correct the pitch surface.

The flatness of the pitch is observed and measured by using a smaller witness flat that stays on the machine at all time. In the case of large diameter optics, this smaller witness flat is what is used to approximate the overall flatness of the machine and the processed optical piece.

This is done because the large optic cannot be taken of the pitch and put back on several times during the work day as the small witness flat can be.

In the past, we managed to obtain a <2nm roughness on Φ25 mm pieces of fused silica. These were measured using an AFM in the INFLPR facilities. We would like to try and obtain a better surface roughness and for this we are considering changing the current abrasive powder in emulsion (water) with a smaller grit size one.

For this, the whole Lapmaster chamber and the whole machine has to be cleaned in order to insure that no particle from the former abrasive powder remains.

The Lapmaster which is now in Pro Optica, is an air bearing pitch polishing lapping machine that can process flat surfaces with a contact area smaller than 400 mm.

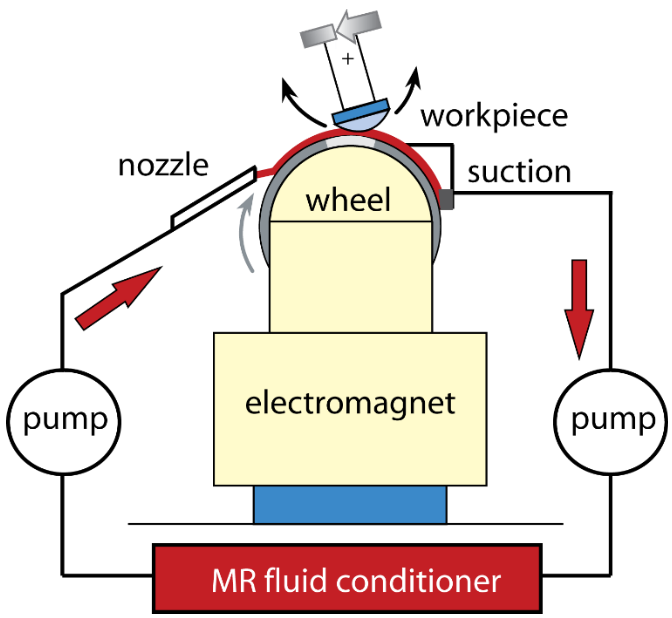
In general the polishing of large optics is done in several ways, as listed below.

I. Manual area polishing[4] - in which a moving arm polishing machine is used to buff the abrasive powder in emulsion on the surface of the optics, this method requires frequent measuring and correction of the optical surface and uses a custom polishing device

II. NC lathes machines[5] - which uses large blocking and polishing devices that are randomly moved by a weighted arm

III. Large optics CNC machines[6] - which are dedicated for large optics

IV. Newer technology MRF (magnetorheological finishing) machines[7] - which uses an abrasive that is put in motion and controlled by a magnetic field

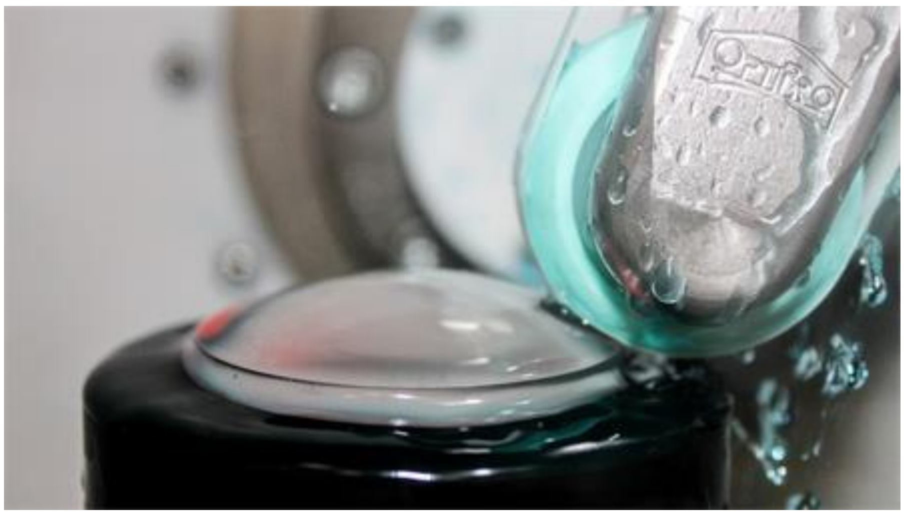


ASPHERIC SURFACES

This project is aimed at finding the best technological way to polish pre-shaped aspherical lenses that can be achieved with the current capabilities made available by Pro Optica.

In this regard, we will try and polish pre-shaped pieces with a dedicated device made for this application.

Usually the aspheric surfaces are grinded and polished[8] by using devices that approximate the local radius and using rotation symmetry given by the working piece which is blocked on a spinning ax.



We will try to custom fit a spherical processing lathe with a special made and fitted device which will have an abrasive pad with a low grit size.

[1] "Manualul opticianului - pentru şcoli profesionale" - C.Zenovei, V.Hâncu, Editura Didactică şi Pedagogică, Bucureşti 1978

[2] "Tehnologia prelucrării pieselor optice" - B.Z.Bikov, A.A.Efremov, V.P.Zakonnikov, V.Salnicov, M.N. Semibratov, Editura Tehnică 1975

[3] Lapmaster-Wolters ""

[4] Photonics "https://www.photonics.com/EDU/Handbook.aspx?AID=61064&PID=4"

[5] OptoTech Germany "http://www.optotech.de/en/precision-optics/hm-12001"

[6] OptoTech Germany "http://www.optotech.de/en/precision-optics/upg-2000-cnc"

[7] QED Technologies "https://qedmrf.com/en/mrfpolishing/mrf-technology/how-it-works"

[8] OptiPro Systems "https://www.optipro.com/pro-series-pro80uff.html"