LabCom NANO-PtoV

Ph D Thesis

Optimization of surface chemistry processes for hyper-polished mirrors

Context

Today, the preparation of the next generation of physics and astrophysics instrumentation requires to address technical challenges in optical fabrication, especially in term of surface figure errors.

While the surface figure error of X-ray mirrors must be minimized to achieve a higher level of energy concentration at the beam lines output of synchrotrons, future Exo-Earth imaging space missions will require extremely precise optics to minimize speckles and achieve a 10^9 star/planet contrast.

To address this challenge the LAM and Winlight Systems have established a partnership in the framework of a ANR Labcom program, and they collaborate with the Institut Charles Gerhardt.

PhD Work

If current polishing techniques can allow to manufacture optical complex surfaces (aspherics) with less than 2nm Root Mean Square (RMS) figure errors, they still need to be improved. To achieve the previously mentioned scientific objectives, one must be able to manufacture mirrors in the 1.0m size range, with surface error lower than 1nm Peak-to-Valley corresponding to a few atomic layers, and a micro-roughness of the order of 1 Å RMS.

To reach this level of accuracy, “non-contact” polishing techniques seem the most appropriate. Within this kind of process, one of the key elements to be studied, in close collaboration with the Institut Charles Gerhardt in Montpellier, is the slurry composition and characteristics, and its interaction with the mirrors surface. Optimized colloidal solutions of various oxide (SiO_2, Al_2O_3, CeO_2, ZrO_2, …) nanoparticles will have to be synthesized and fully characterized within ICGM, and implemented in polishing processes at Winlight and LAM.

The work will consist in optimizing the slurries for silicon but also for glasses that are used for astrophysics (Silica, Zerodur): minimizing sub-surface damage, optimizing Material Removal Rate (MRR), optimizing micro-roughness. The parameters to be optimized are the size, the chemical composition and the surface state of the nanoparticles, the additives of the slurry (salts, surfactants) and its pH and viscosity.

The implementation of the slurries in polishing processes will be done at LAM and Winlight within already existing polishing workshops. Results about the obtained surface quality parameters will be analysed within the metrology labs of LAM, ICGM and Winlight (electronic microscope, AFM, X-ray diffraction, XPS, …).

Cursus and Skills

Master M2 or engineering school diplomas in materials chemistry (Sol-Gel, hydrothermal synthesis, surface chemistry, characterization of nanoparticles, optical characterization of surfaces, roughness measurement).

Constraints and risks

The work will take place at ICGM in Montpellier with short travels/stays at LAM and Winlight premises in Marseille and Pertuis.

Risks associated with nanoparticles handling will be covered by specific safety training (compliance with health and safety rules and regulation in force in the laboratories).

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