



High Precision Optics and Optical Systems

Italian Space Optics Manufacturing, an Industrial Perspective

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A conference devoted to developing the Italian involvement in TOLIMAN

Outline



- Media Lario overview
- Optics and Optics Manufacturing processes
- Repli-formed Optics™, a new paradigm

Company Overview



- Media Lario S.r.l. founded in 1993
- Located in Bosisio Parini, Italy
- Employing primarily engineers, scientists, high-tech mfg personnel
- Serving global advanced optical markets...
- and major Aerospace customers including



Media Lario production facility, Bosisio Parini, Italy



Located in an area of high tech manufacturing and optics expertise

*High precision optics for Space
X-Ray Telescopes*



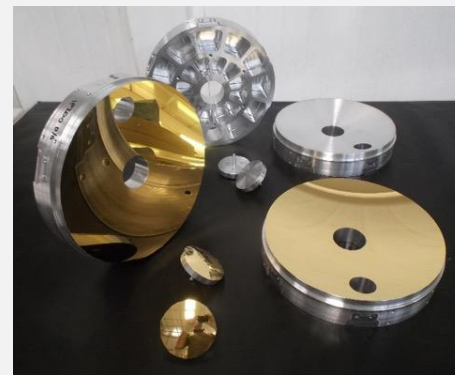
Satellite Optical Components



Satellite Optical Systems



High-volume Precision Optics



Manufacturing Facilities



- 3,400 sq meters (34,000 sq feet) of advanced manufacturing space
- Diverse processes – electroforming, deterministic figuring and polishing, hot and cold shaping
- Over 1000 sq meters ISO 5/6 cleanroom for optical integration and metrology
- 18 multi-ton cranes throughout facility for large scale assembly, handling



Space Qualified Assembly Areas in Media Lario

Mirrors Manufacturing Capabilities

Glass and Metal Optics for Scientific Missions

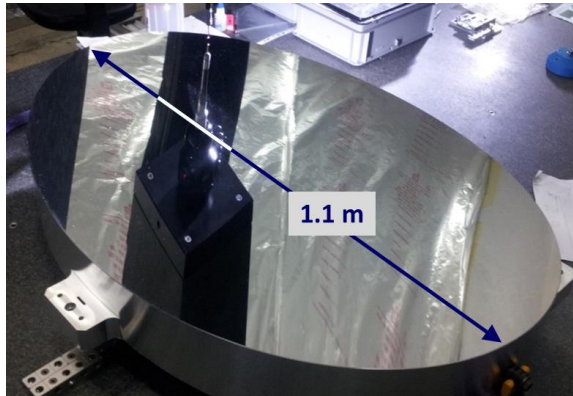
**CHEOPS
ZERODUR®
mirror**



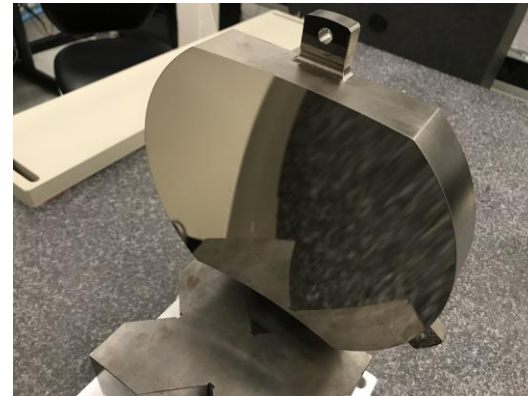
**PLATO
lens L1**



**ARIEL
aluminium
prototype**



**FLEX
aluminium
mirror**





CHEOPS ZERODUR® primary mirror



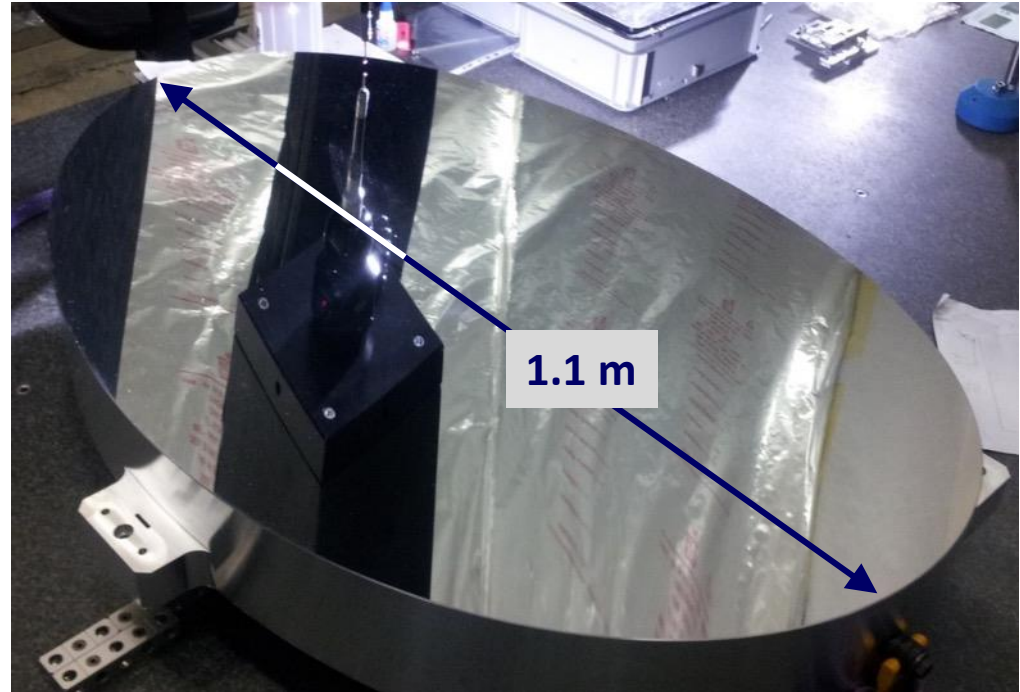
PLATO aspheric lens

- Extensive work done on glass material including ZERODUR® space qualified glass
- Finishing specs better than 20 nm shape accuracy, 1 nm surface roughness

Aluminium Mirrors



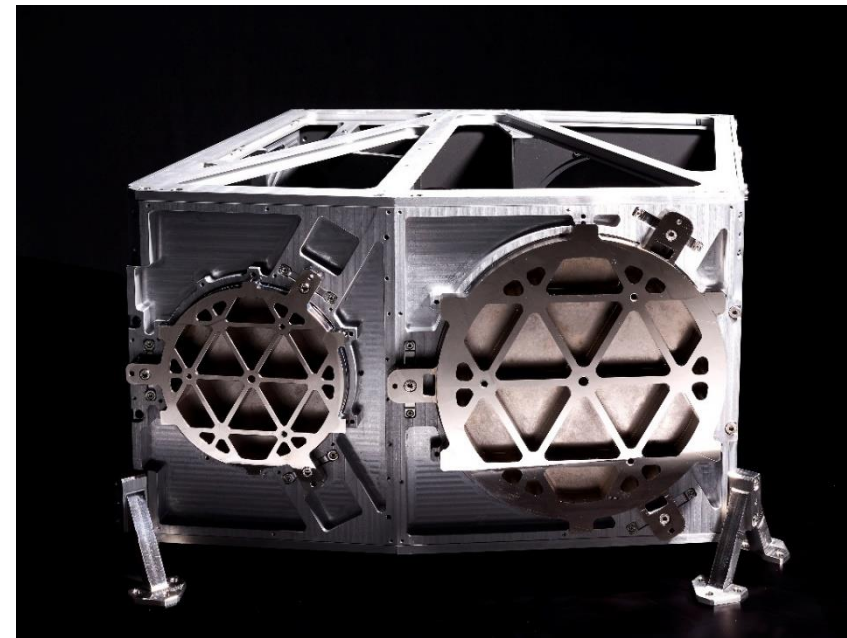
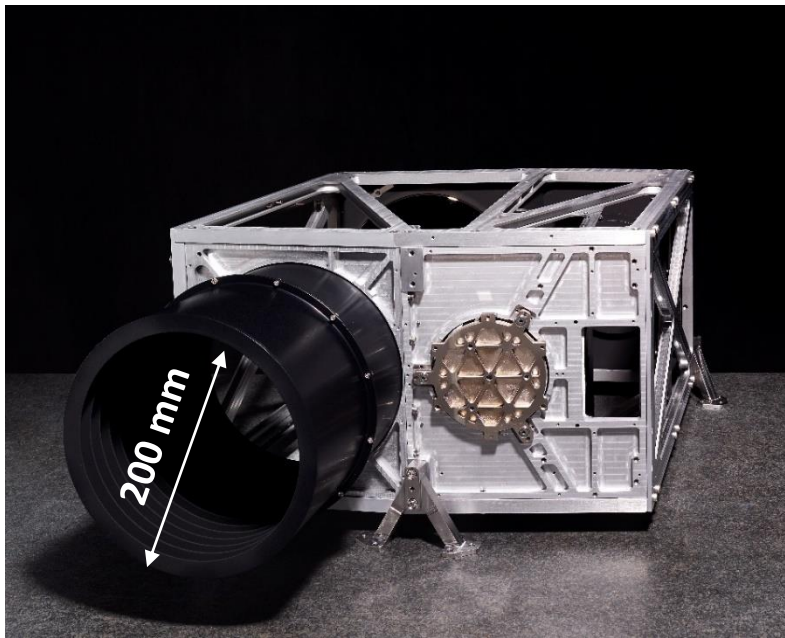
AlSi40/NiP mirrors for STREGO Payload



Al 6061 primary mirror prototype for ARIEL mission

- Several years invested with agencies and large aerospace co's on Aluminium alloy mirrors
- Have produced mirrors uncoated and coated to achieve final requirements.

Athermal Aluminium Payload Architecture



Athermal architecture for STREEGO multispectral optical payload

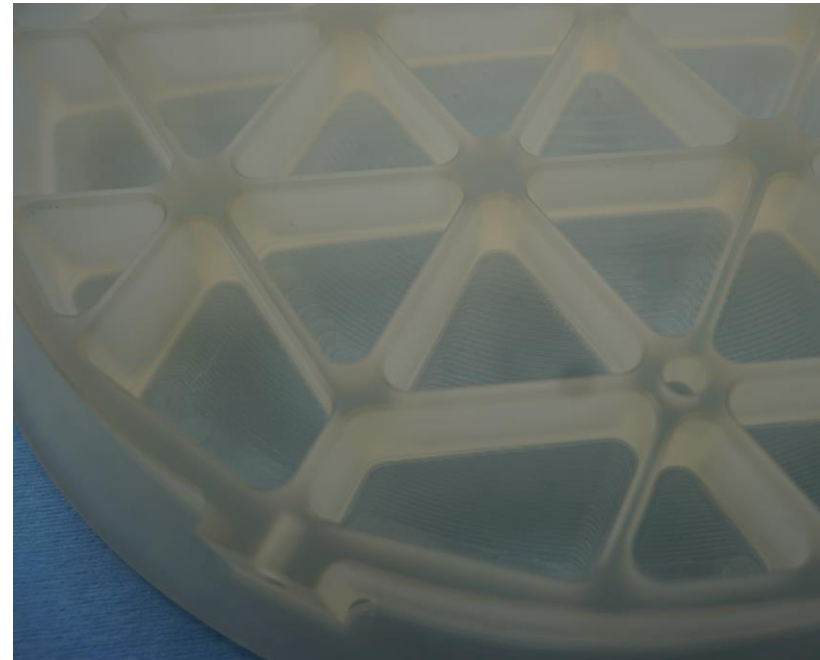
- New AlSi40 Aluminium alloys are CTE-matched to Nickel-Phosphorus hard coatings
- This allows athermal designs that reduce thermal control requirements on platform
- Aluminium also allows to integrate mechanical interfaces and references in the mirror

1 kg → 20 kg/m²



Light-weighting on 250 mm AlSi/NiP mirror

1 kg → 20 kg/m²

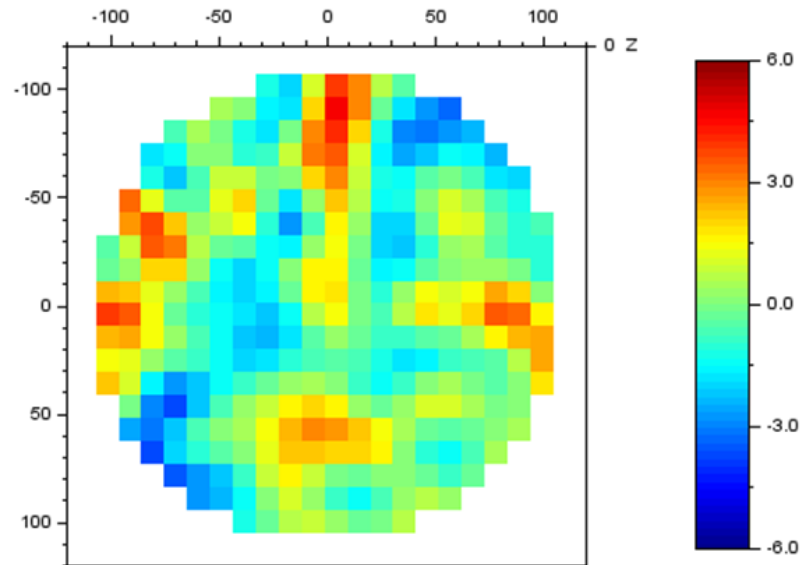


Light-weighting on 250 mm ZERODUR® mirror

- Both materials can be light-weighted up to 70-80% mass saving
- This results in mirrors with typical 20 kg/m² areal mass for 250 mm diameters
- Light-weighting does not cause quilting effect (i.e. print through) during polishing

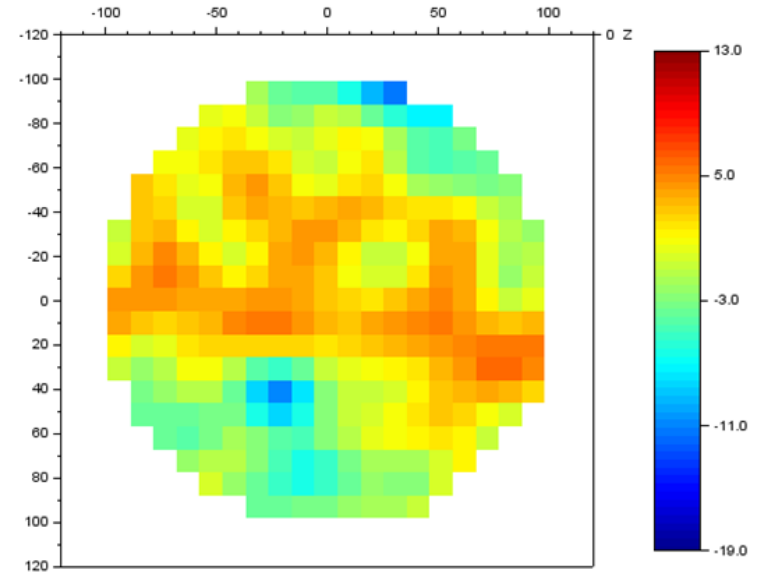
First Generation of Aspheric Surface

250 mm AlSi40 substrate after pre-machining



MSE = 1.9 μm RMS

250 mm ZERODUR® substrate after machining



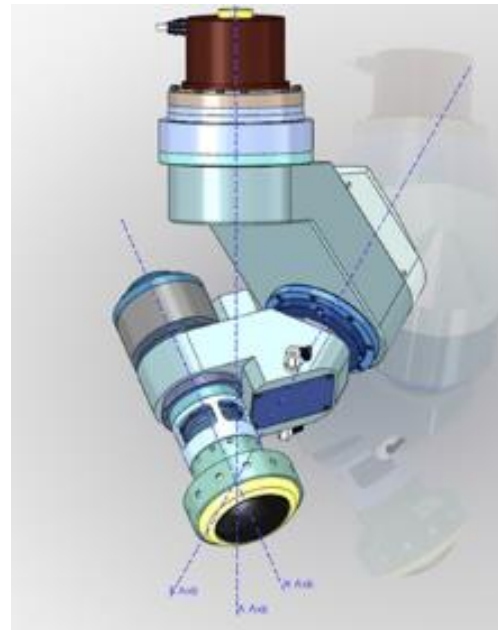
MSE = 3.7 μm RMS

- Aspheric surface is machined to 10-15 μm PV from nominal.
- Aluminum substrates are then diamond turned to better than 1 μm PV precision from nominal

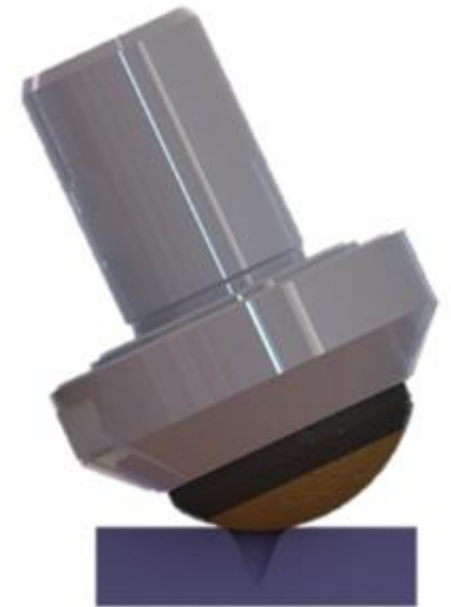
Deterministic Figuring & Polishing



ZEEKO IRP 600X in Media Lario



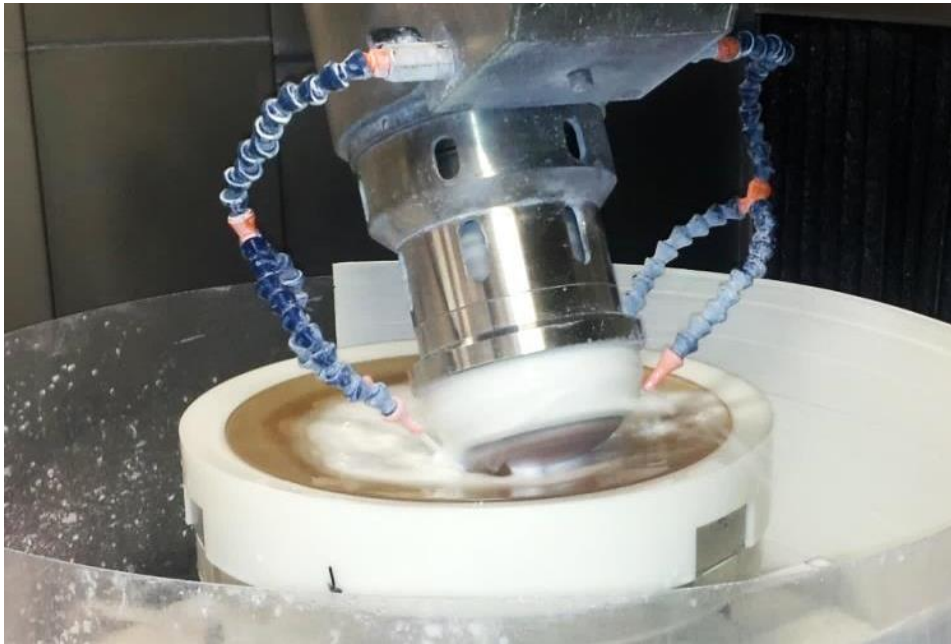
7-axis operation of the Bonnet



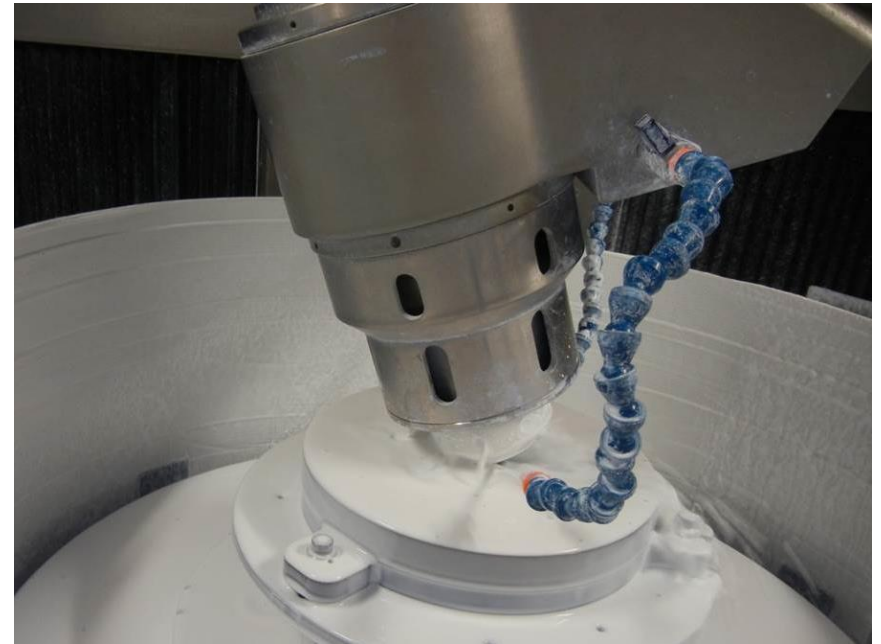
Bonnet-Mirror contact area

- The bonnet (or polishing tool) is mounted on the head of a multi-axis CNC machine
- Dwell map calculated from convolution of bonnet transfer function with mirror surface error
- Process corrects mirror shape error by selective removal of material on the mirror surface

Polishing on ZERODUR and Al/NiP Substrates



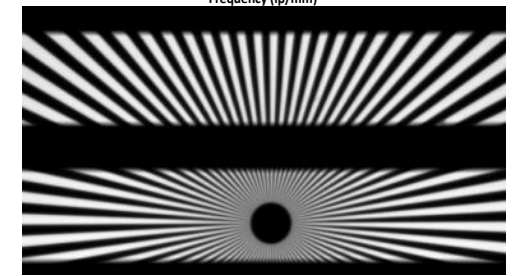
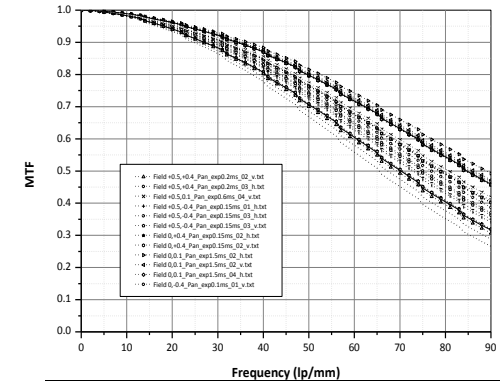
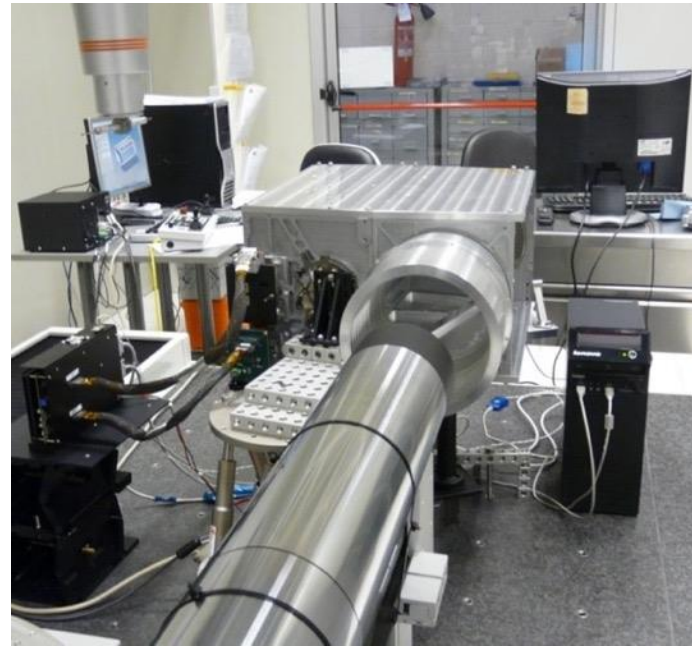
330 mm ZERODUR® mirror under Bonnet polishing



200 mm AlSi40/NiP mirror under bonnet polishing

- Shape accuracy better than 15 nm – aspheric, off-axis, freeform designs for UV, visible, IR
- Size up to 1.2 m or larger – Glass, Quartz, ZERODUR®, Nickel coated Aluminium substrates

State of the Art Metrology

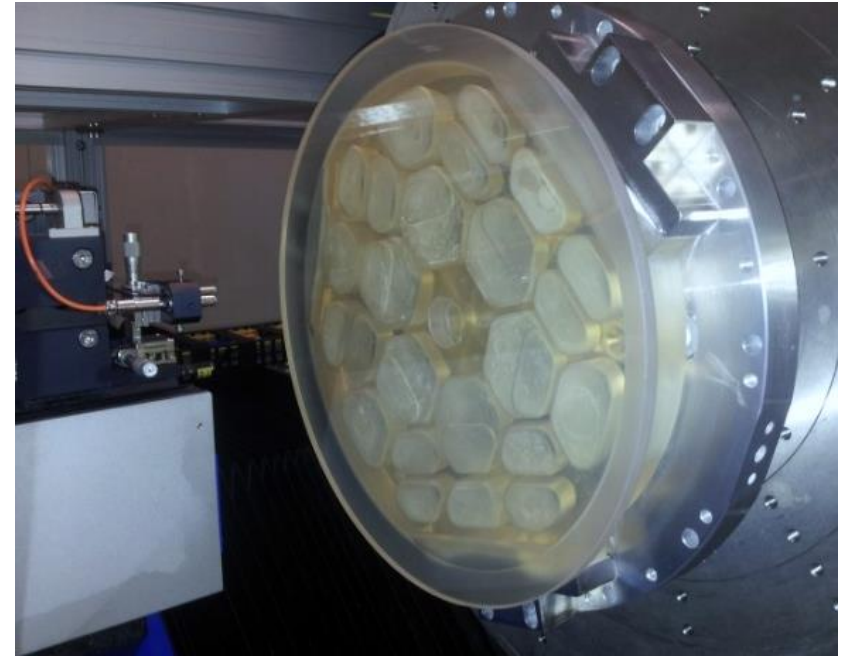


- Large scale on-site metrological capabilities for dimension, shape and surface quality
- Interferometer and other tools for wave front measurements
- Image distortion and surface roughness measurements

Non-Contact Optical Profilometer



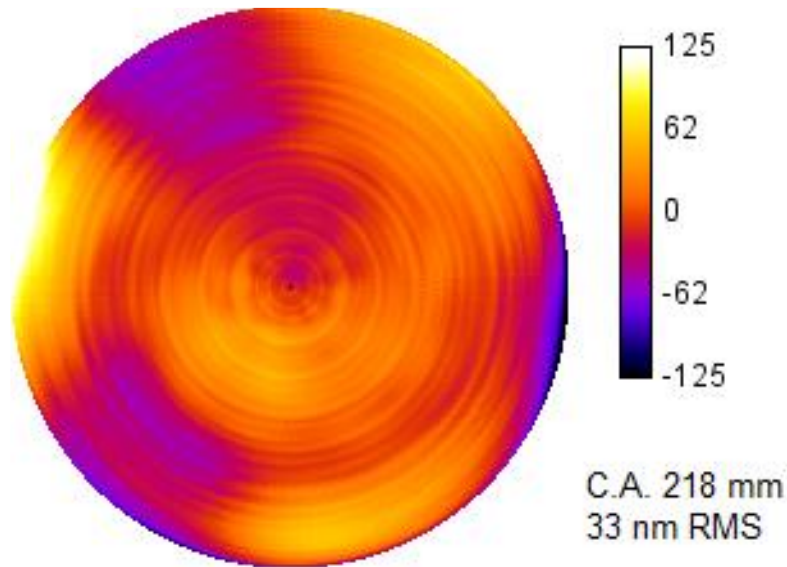
MPR 700 optical profilometer



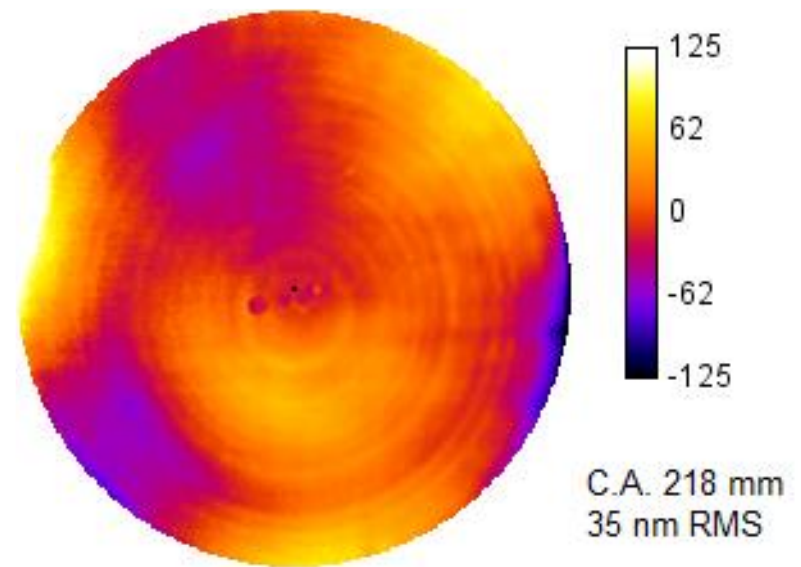
CHEOPS mirror on profilometer

- Optical profilometer provides accurate measurements on ground substrates, including ROC
- 1 mm lateral resolution allows measurement of machining mid-frequency patterns

Complementary Metrology Capability



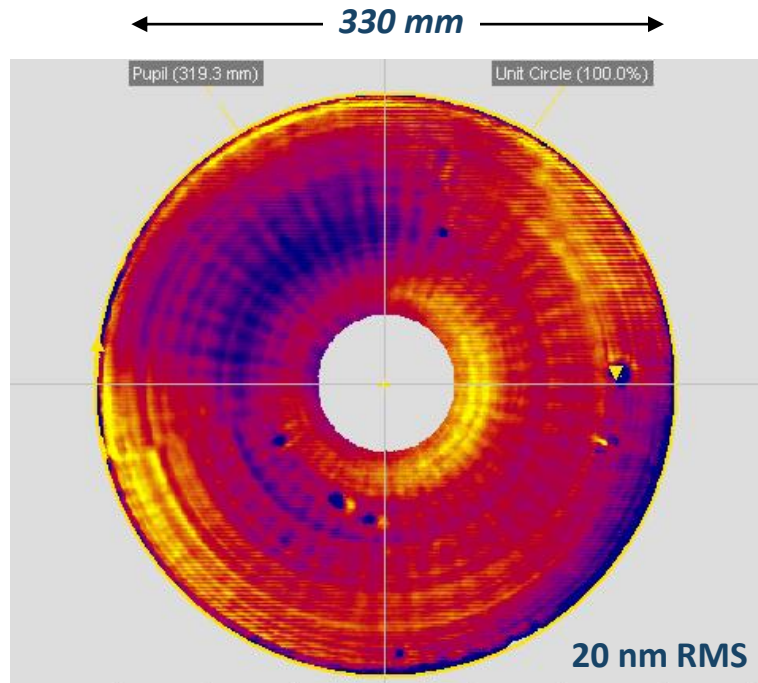
Optical Profilometer Measurement



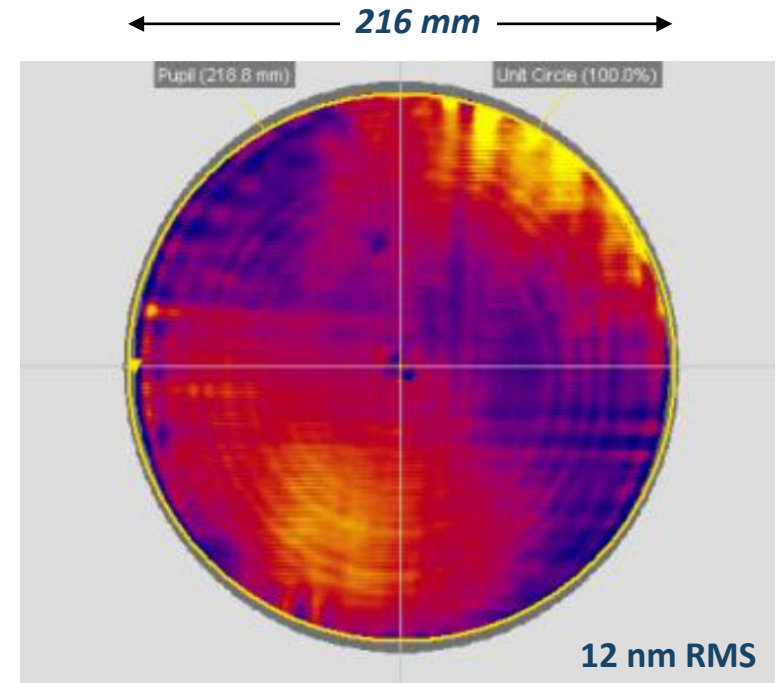
Interferometric/CGH measurement

- Profilometer is accurately cross-correlated to interferometer/CGH reference
- Profilometer provides high range, fine lateral resolution, and absolute ROC measurement

Final Interferometry Measurements



ZERODUR® mirror



AlSi40/NiP mirror

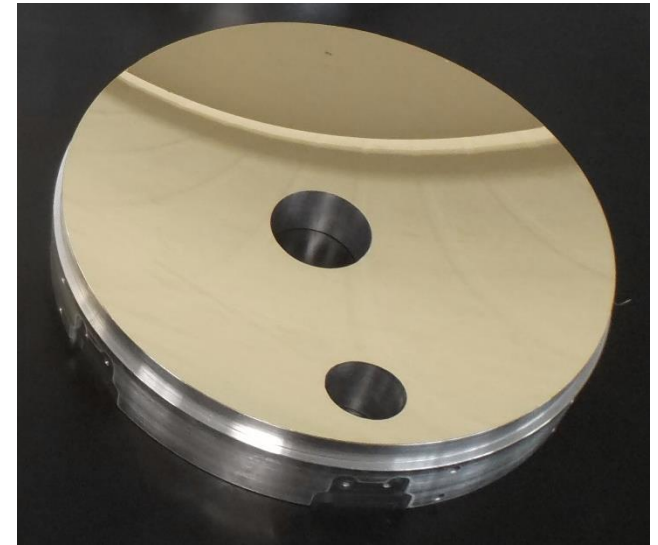
- Interferometer/CGH can measure any aspheric, off-axis, freeform design
- Manufacturing processes proven to better than 20 nm RMS on large size mirrors
- Surface roughness finish of 1 nm RMS on both materials

Repli-formed Optics™ - A Paradigm Shift

Characteristics of Repli-formed Optics™

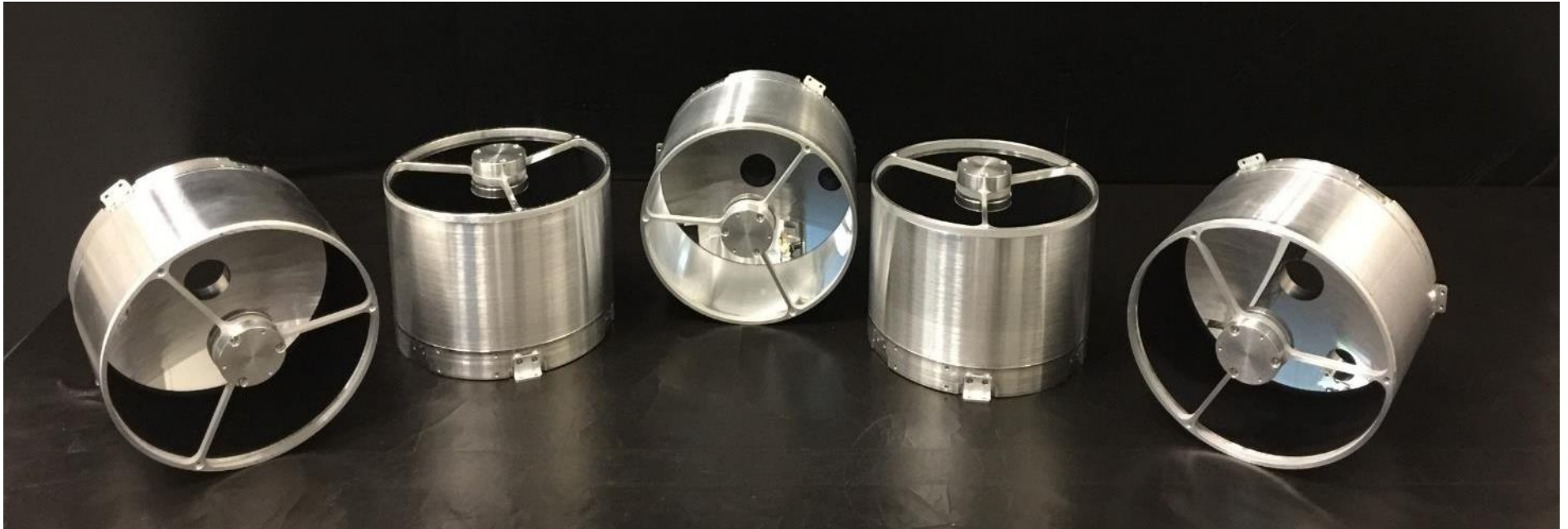


- It is a replication technology
- Production throughput of 1 mirror-per-day for each mold
- Cost of optical mold is amortized over multiple mirrors
- Inexpensive non-optical support structure
- Suitable for high volume and cost sensitive applications



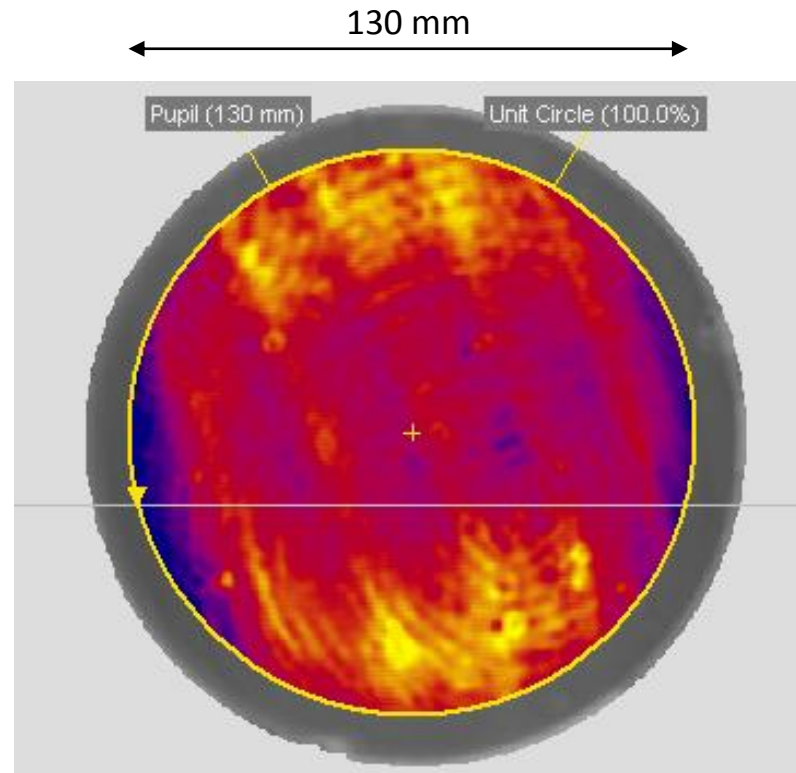
200 mm Repli-formed Optics™

LIDAR Telescopes with Repli-formed Optics™



LIDAR telescopes produced in series with Repli-formed Optics™

- Production series of multiple telescopes for LIDAR application
- Protected Aluminum optical coating for operating wavelength
- 57 μrad average angular FWHM value of the PSF, with a standard deviation of 11 μrad



- 11 nm RMS demonstrated on 130 mm mirror prototype by Repli-formed Optics™ technology
- Development ongoing for optical communication terminals

Conclusions



- Up to 1.2 m manufacturing capability for ZERODUR® or Aluminium optics
- Aspheric, off-axis and freeform designs
- Repli-formed Optics™ is our response to large volume and cost sensitive applications



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