Optical prototyping @ VUB
Brussels Photonics (B-PHOT)

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What and where is B-PHOT's Photonic Inovation Center

Visit our web page and you can find out more on our labs, staff and R&D

What we do:

- Simulation and design of photonic devices
- Prototyping and manufacturing
- Metrology and Quality control
- Industrial prototypes
- Proof of concept demonstrators

B-PHOT is located in the Flanders countryside. It houses design and development group, production and prototyping facilities, metrology section as well as many research laboratories ranging from bio-photonics to advanced silicon production and characterization.

B-PHOT employs 45 Research and Innovation Experts, many Technology Experts and Business Developers.

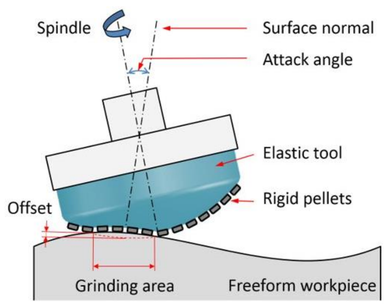
Founded in 2012 it deals with fundamental, applied and industrial photonics research and development.
It has been involved in development of industrial, automotive, biomedical and R&D projects over the last decade.

Silicon prototyping: grinding & polishing

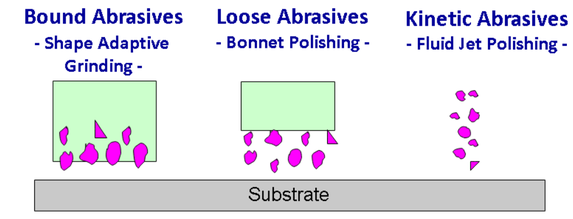
- Grinding: raw shaping form
- Polishing: reaching required roughness
- Corrective polishing: adding shape corrections

- **Grinding/polishing aspherical surfaces – a challenge!**

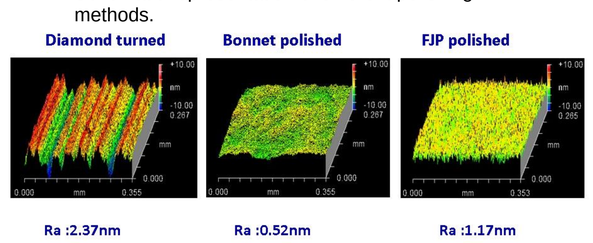
-Requires skill of CNC operated production machines
-Requires adaptive tools of sub-aperture size



Different polishing methods and tools give specific surface roughness patterns. For freeform high precision optics as first step shape adaptive grinding is favourited and for polishing phase fluid jet polishing or Bonet polish are recommended.

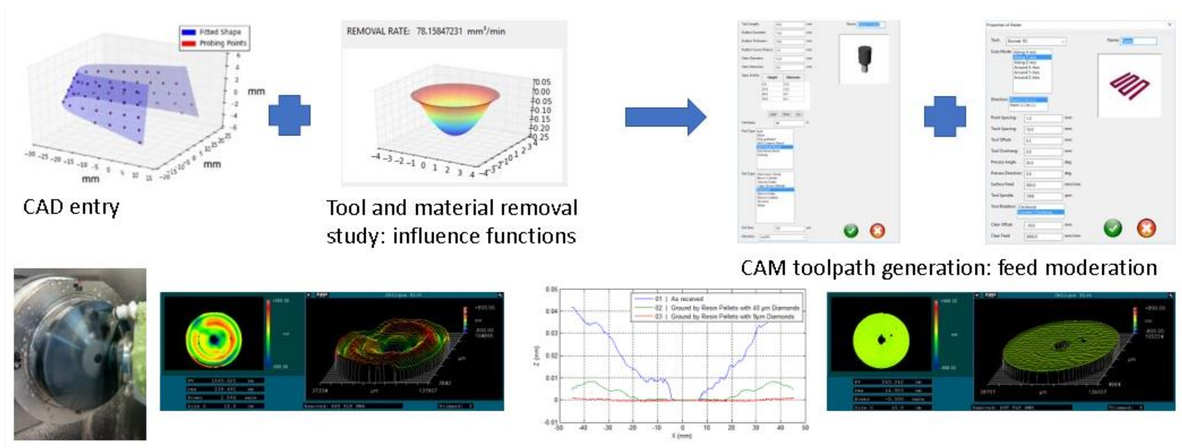


Schematic representation of different polishing methods.

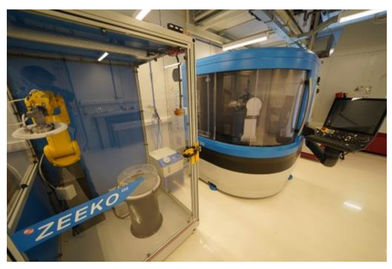


Surface finish for different production procedures

Corrective grinding and polishing



Polishing, diamond turning and ion beam figuring

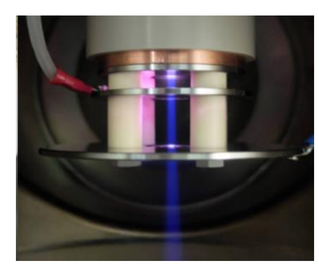


Zeeko IRP 200 MK2 7-axis polishing

- Sag tool grinding/polishing
- Bonet tool polishing
- Fluid jet polishing
- Zeeko robot fluid jet polishing
- Standard fluid jet slurry
- Ultrasonic assisted fluid jet slurry

Nanotech 350 FG diamond turning

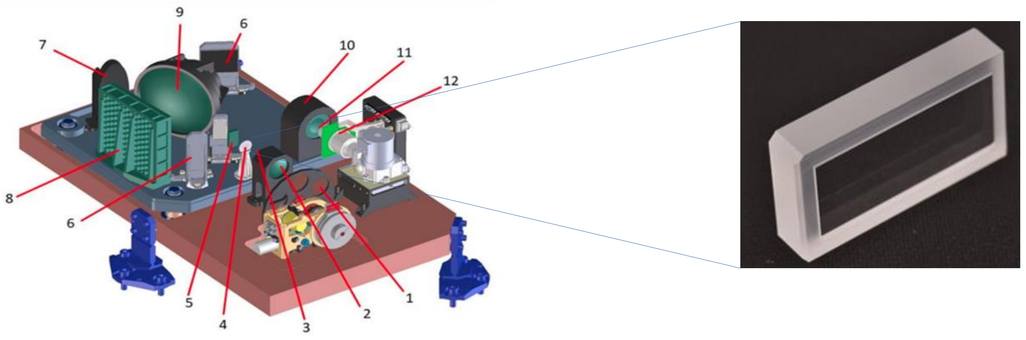
- Of-axis, toric and freeform components
- Extreme precision and stability



Ion beam figuring

- cutting edge technology for production of extreme precision optics
- only technology that can tackle mono-crystalline Silicon

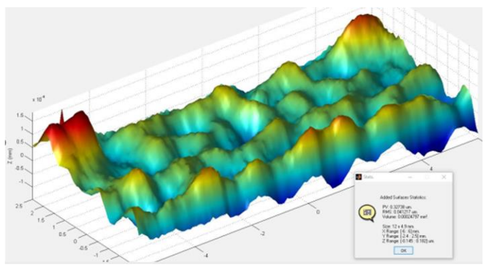
Case study I: Corrector plate for ESA/NASA Venus mission



ESA/NASA *EnVision* planetary mission to Venus (2032)
Phase B1: fully functional instrument

Venspec-H high-resolution nadir echelle grating spectrometer instrument for 1.0–2.5 µm and 7.32° by 0.084° FOV
Gas sensing, monitoring volcanic activity

Demonstrating the power of freeform optics in canceling optical aberrations. Silicon plate is custom made phase mask that introduces carefully calculated phase-distortion that cancels out majority of beam aberrations.
λ/10 PV surface shape requirements



Inferred surface roughness from w..l. interferometry

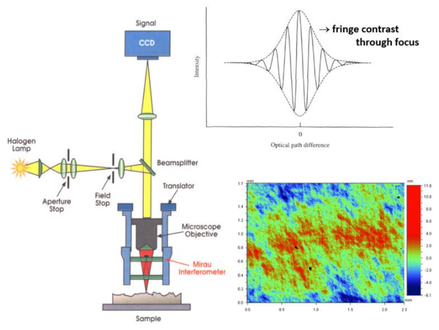
High precision surface metrology

Zygo Veryfier HDx Fizeau Interferometer

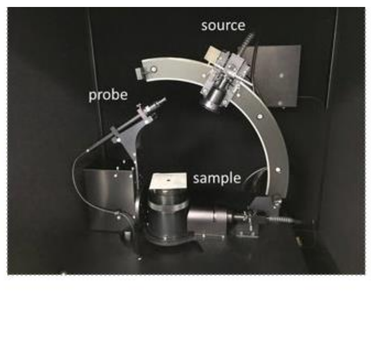
- Full field 4'' and 6'' aperture
- Surface shape
- Mid spatial frequenciers
- Wide selection of RoC for Nulling plates

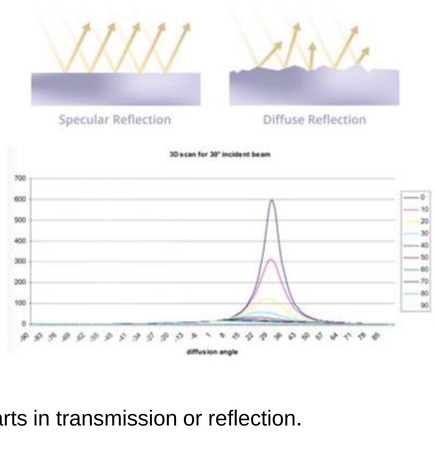
Zygo white light Interferometer

- 2x, 5x, and 20x objectives
- White light Mirau interferometer
- Low and mid spatial freqs
- Fast and automatized fringe detection
- Possible stitching of maps for large samples



Scaterometry





Measuring light scattering profile from silicon blanks on machined parts in transmission or reflection.
For illumination white light source with a bank of filters is used.
It is possible to measure scattering signal on reflection and transmission.
Detection is conducted via detection of integrated flux or spectral analysis
Easy calculation of BRDF and BTDF – Important for GW detector optics!

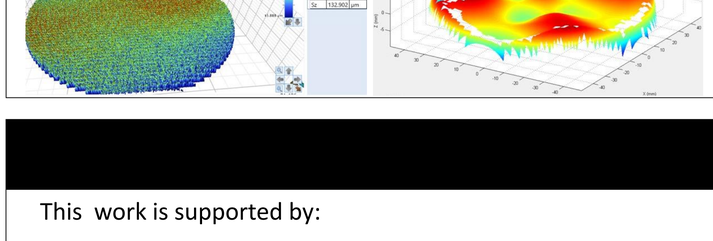
Case study II: Crystaline silicon polishing with sag tools and HTRS mirrors metrology for 3G GW detectors

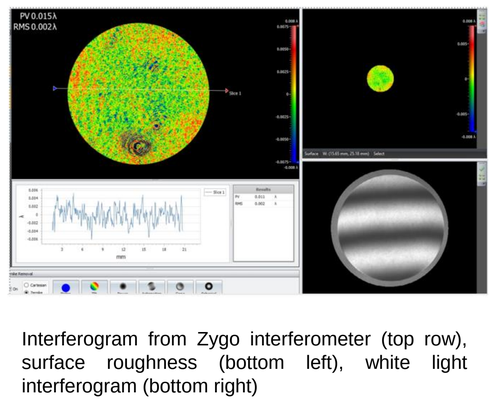
Diamond grit embedded in a matrix (Ni or epoxy)
No loose abrasive, water as coolant. 100Mm semiconductior grade Si wafer

First step: removal of previous subsurface damage
Fast tool and workpiece rotation, fast removal of 10's of microns
First shaping if needed

Second step: corrective polishing feedback by metrology step down in grit size

Strong effect of (111) crystal planes





Interferogram from Zygo interferometer (top row), surface roughness (bottom left), white light interferogram (bottom right)

Support and acknowledgements

This work is supported by:

- iBOF 21/084 *Unlocking the Dark Universe with Gravitational Wave Observations: from Quantum Optics to Quantum Gravity* in order to conduct a research on novel optical configurations for I/O resonant cavities using free-form optics.
- *FWO International Research Infrastructure* to study Stray light mitigation based on scatterometry data and to master Silicon mirror fabrication
- *Interreg ET-Pathfinder* for procurement of capital infrastructure for Silicon mirror fabrication and metrology
- *Interreg North-West Europe* OINWE for diamond turning
- *Interreg Vlaanderen-Nederland* for infrastructural investment in B-PHOT

XI Belgian-Dutch Grawitational wave meeting. Maastricht, Neatherlands. October 2023