Nano characterization of scratches and defects on polished glass

The evaluation of many optical material surfaces requires nanometer resolution on relatively large and medium-sized surfaces. Is this also true for spectacle lenses?
Scratches occur on the surface of spectacle lenses both during the manufacturing process and later when the lenses are used (cleaning, storage). In order to answer the above-mentioned question, it was necessary to realistically simulate the forces applied, to measure the scratches caused by them and thus to find out whether they significantly influence the surface properties of the coated lens.
The present paper is dedicated to these tests and analysis.

1. Tribological impact: Measure the friction behavior of spectacle lenses

Objective of experiments:
Measuring the tribological impact of shear forces - friction experiment at different low loads

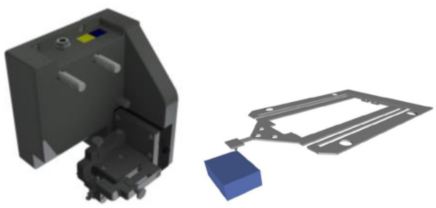
Sample and upper tool:

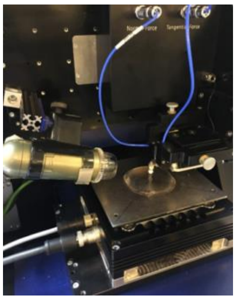
Spectacle lens +3.25 +4.50 50

5 mm Ø corundum (Al_2O_3) ball as counter-material

Instruments used for experiments and parameters of friction experiments:

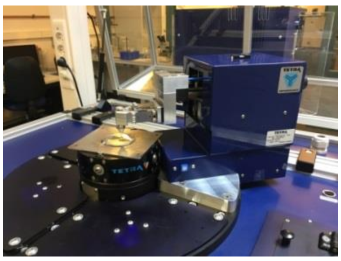
Multi-modal tribology tester BASALT-N2

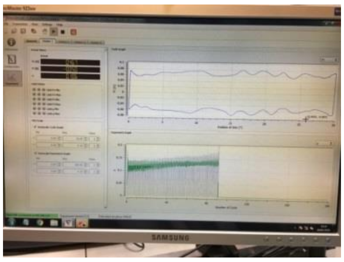




Complete test set-up of the BASALT-N2 tester

10N pin-on-disc tribology tester BASALT-S2





Complete test set-up and GUI of the BASALT-S2 tester

Tests performed:

Test ID	Tester type	Sensor	Load (N)	Speed (mm/s)	Stroke (mm)	Accelera-tion (s)	Counter material
24446	BASALT-N2	Dual spring*	0.5	10	3	0.1	5mm Ø Al_2O_3 ball
24447	BASALT-S2	Strain gauge	0.5	10	3	0.1	5mm Ø Al_2O_3 ball
24448	BASALT-S2	Strain gauge	1	10	3	0.1	5mm Ø Al_2O_3 ball
24449	BASALT-S2	Strain gauge	2	10	3	0.1	5mm Ø Al_2O_3 ball

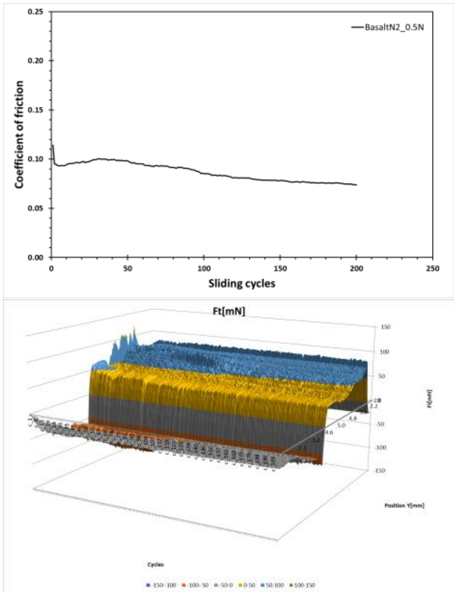
*Basalt N2 with light load sensor (dual spring cantilever)

Parameters:

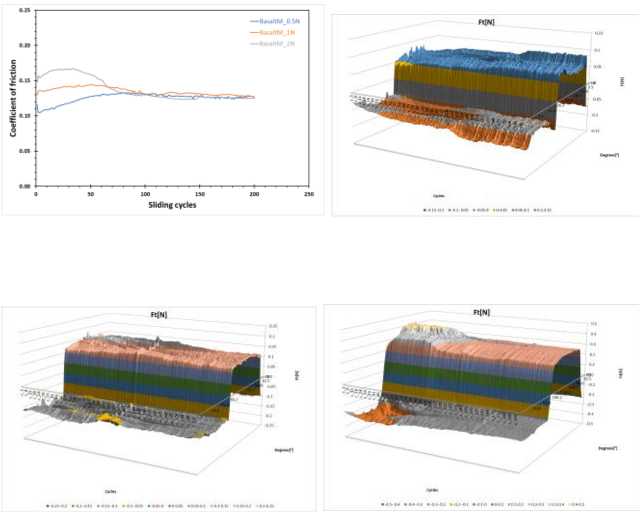
- Linear reciprocating movement
- Parameters: 200 cycles each, 10 mm/s, 3 mm stroke
- Interface: Al_2O_3 ball (Ø 5mm) to glass
- Normal load: 500mN (test 1), 1N (test 2), 2N (test 3)
- Results: F_T data, CoF data
- Load mode: linear load, vertically controlled pressure to the samples

Coefficient of friction (CoF) and triboscopy results:

BASALT-N2



BASALT-S2

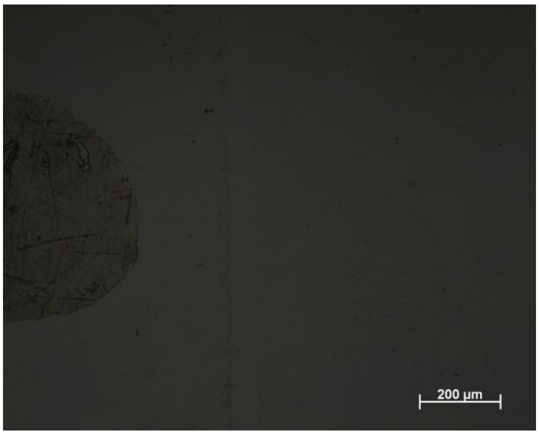


3D graphics: visualization of friction force @ 0.5N, 1N and 2N, respectively. By courtesy of Falex Tribology BV

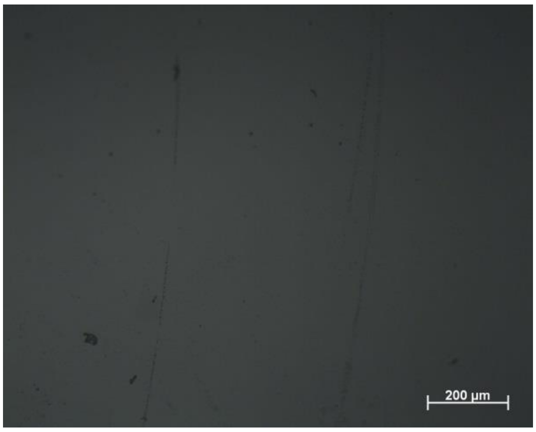
Above triboscopy graphs: X-axis - the cycle, Y-axis - the position within the cycle, Z-axis - the frictional force

Triboscopy enables the user to a 3D representation of the frictional force, during each cycle and throughout the test. The graphs illustrate that there are adhesion phenomena (local increase of friction); it can therefore be concluded that there are variations in the homogeneousity of the frictional force.

2. Surface after friction experiments: tiny wear tracks imaged by optical microscope

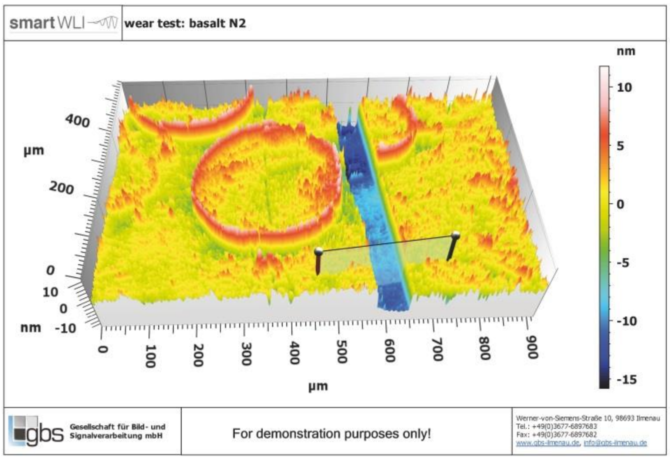


BASALT-N2 0.5N wear tracks, 10x magnification

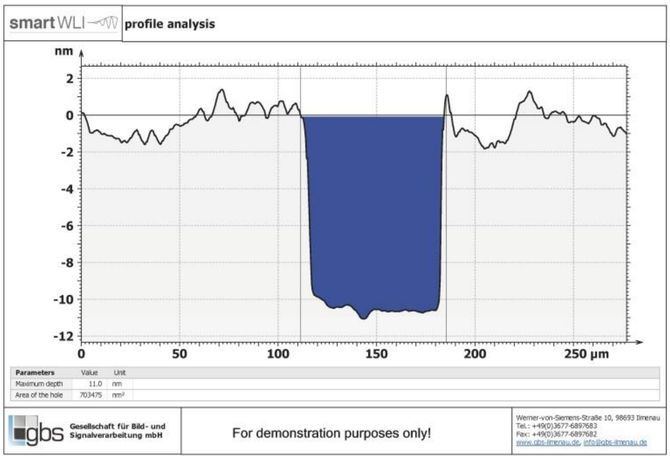


BASALT-S2 (0.5N, 1N, 2N) wear tracks, 10x magn.

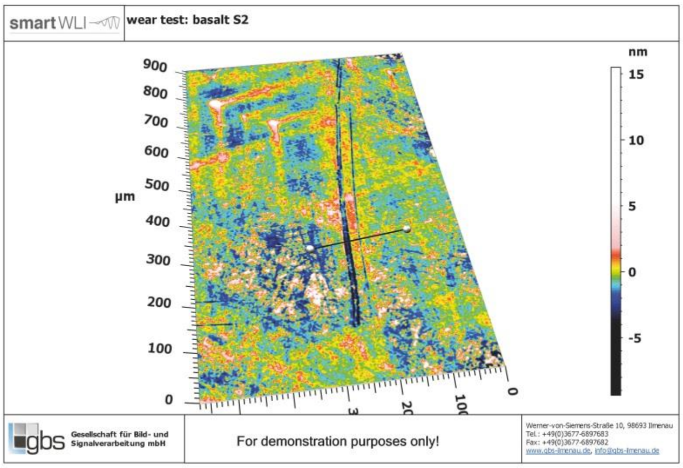
3. Surface 3D characterization after friction experiments. Conformity to ISO 25178 (profile and texture) and ISO 4287 (surface roughness) standards



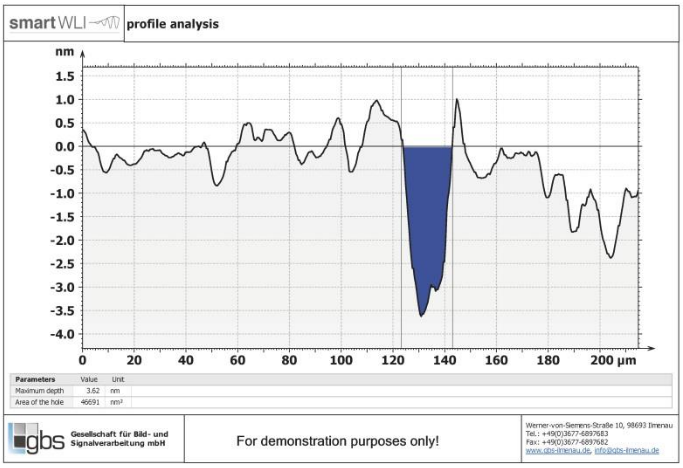
BASALT-N2 0.5N wear track



Parameters	Value	Unit
Maximum depth	11.0	nm
Area of the hole	703,475	nm²



BASALT-S2 (0.5N, 1N, 2N) wear tracks



Parameters	Value	Unit
Maximum depth	3.62	nm
Area of the hole	46,691	nm²

User benefits. Relevance for material inspection

On hard glass surfaces, minimal scratch marks (≤ 10nm deep and wide) occur when forces of 0.5 to 2N are applied, which need not necessarily be measured on spectacle lens surfaces. At present, the cross-cut tests and steel wool tests (abrasion tests) that are common in this industry are probably sufficient.

The case is different with plastic spectacle lenses, which are usually coated and much softer than glass surfaces. Here, scratch marks could occur which are larger and significantly change the surface properties such as antireflection coating, refractive properties or UV protection. We recommend that manufacturers have sample tests made to check this.

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