SUMMARY OF THE STUDY ON EFFECTIVENESS OF LENS SURFACE CLEANING WITH THE *LENSPEN*™ CARRIED OUT AT THE SURFACE SCIENCE LABORATORIES OF SIMON FRASER UNIVERSITY BY JC&T SCIENTIFIC CONSULTING

OBJECTIVES

The primary objective of the study was to examine the safety of the cleaning composition to the antireflection coatings of the optical surfaces and to detect any deposits left on the lens surface after multiple cleaning procedures.

The secondary objective was to measure the generation of electrostatic charges during lens cleaning procedure.

EXPERIMENTS

Three sets of experiments were conducted in order to obtain full insight into the mechanism of cleaning capabilities of Lenspen.
This was done through thorough investigation of various angles of the Lenspen cleaning procedures.

1. In order to investigate possible abrasiveness of chamois/cleaning composition combination to the lens coating:

Microscopic observation was conducted and microphotograph documentation of the lens antireflection coating state after multiple cleaning was obtained. Investigation was performed with the use of a standard stereoscopic microscope under 100xmagnification and with the use of dark field, circular light source illumination.

In a series of microscopic observations of a virgin lens surface and the lens surface subjected to a series of cleaning procedures with Lenspen it was observed that no significant changes in the state of a lens surface took place after 5, 10, 15,20,25, and 30 minutes of cumulative cleaning.

2. In order to investigate the magnitude of the inter-diffusion of the cleaning composition into the outer layer of antireflection coating due to prolonged rubbing of the lens surface with Lenspen:

AES (Auger electron spectroscopy) investigation of a lens surface subjected to multiple cleaning procedure with Lenspen have been carried out at Surface Science Laboratory of Simon Fraser University, Hurnaby B.C.

Since the sampling depth of the AES ranges from 5 to 20A it was possible to investigate extremely thin surface layers. Thus the aim of these investigations was to obtain an insight into the thickness of possible carbon blacks deposits left on the lens surface after prolonged rubbing of Lenspen on the lens surface and possible interdiffusion of carbon blacks into the antireflection coating.

The AES investigation were carried out using a PHI 595 instrument (SAM) combined with in situ ion milling. the Auger spectra of the lens antireflection coating layer were obtained with a 3keV primary electron beam of 10^{-7} A. Art^{+} sputtering was performed with PHI sputter gun at an accelerating voltage of 3keV. The argon ion beam was rastered over an area of 1 to 2 mm^2 and the ion current was ~200µA/cm2.

Two main types of measurement were performed: spot analysis and elemental depth profiles.

The AES spot analysis of a virgin lens surface revealed that the antireflection coating was composed ofMgF2. The main peaks observed (C, 0, F, and Mg) indicate that a clean, virgin surface of the lens element under investigation contained on its surface only a very thin layer of C and O-elements commonly found on any surface exposed to the laboratory environment. Strong signals of F and Mg indicated that C was present as few mono-layers only.

The following examinations of the antireflection coating surface were carried out:

AES surveys over,

I virgin surface (prior to any treatment),

II contaminated surface (after marking the surface with a fingerprint mark),

Ill surface cleaned with Lenspen (single cleaning procedure).

In separate experiments thickness of C deposits left after rubbing the investigated lens surface with Lenspen for 30 minutes was examined. this was done through sputtering of Ar^+ and monitoring C signal against depth sampled (elemental depth profiles of C).

The elements that were monitored in these examinations were thus:

a) carbon C-(peak position ~270eV)

b) fluorine F-(peak position ~650eV) and

c) magnesium Mg-(peak position ~1174eV)

The AES surveys over a virgin surface revealed two very intense peaks of F and Mg. (Some AES data indicated presence of0 and Si which might indicate defects in antireflection coating and occasional exposure of the substrate, $SI0_2$ to the Ar^+.

When surveying surface marked with fingerprint mark, AES spectrum exhibited a very intense peak of C with traces of 0 and N, usual composition of hydrocarbons comprising fingerprint mark.

In the survey of surface cleaned with Lenspen strong signals of F and Mg could be clearly seen again indicating removal of the fingerprint residue from the lens surface. Comparison of data obtained in surveying the lens surface state in different conditions indicated that average thickness of C on the lens surface did not exceed 30Å after single cleaning procedure.
The elemental depth profile measured after several cleaning procedures indicated that the thickness of C deposits did not exceed 90A. Elemental depth profile was further examined after 30 minutes of rubbing lens surface with Lenspen and registered again no more than 60-90Å of C deposits indicating that basically there is no inter-diffusion of C into the antireflection coating and registered thickness of 60-90 Å is totally negligible.

3. In order to investigate possible generation or removal of the surface electrostatic charges during the cleaning procedure with Lenspen:

Experiments have been carried out to measure the polarity and magnitude of

electrostatic charges generated during cleaning procedures with Lenspen. A Faraday cup and Keithly 616 digital electrometer were used to carry out measurements.

The magnitude of the electrostatic surface charge generated during the lens cleaning is an important factor influencing effectiveness of the cleaning procedure. These electrostatic charges accumulated on the insulator surface (glass, acrylic lenses, or composite material lenses) attract small dust particles due to so called dielectric polarization and very frequently substantially affect lens cleaning effect. Thus, the ability to generate or removal of the electrostatic surface charges by the cleaning method is a factor enhancing or limiting cleaning effectiveness.

The comparative results obtained during investigation of the polarity and the magnitude of the electrostatic charges generated on the lens surface were quite surprising and are described in tables 1,2,3,4,5, and 6.

Inspection of Table 1 and table 2 indicates clearly that the smal1est changes accumulated after lens polishing with five different means were observed for chamois/carbon black association. The respective ratio of the changes accumulated for plastic lenses ranges from a factor of 5 to 15, depending on the material applied. It is interesting to point out that the application of dry chamois (Table 4) leads to a significant build-up of electrostatic charges exceeding those generated by the composite by a factor of 8. This remarkable result indicating dramatic changes in the chamois properties upon its saturation with cleaning composition. It has been observed in many cases that freshly activated tip of the Lenspen generated smallest amount of charges and the magnitude of these charges increased with the time of the tip use. The observations of the charges generated on the glass lenses could generally be applied to the plastic lenses although the respective ratio of the charges generated is smaller and varies between 1.1 and 3.5. The smaller ratio of the generated charges might have its source in rather poor saturation of the device tip with the cleaning composition.

Additional measurements conducted with a chamois containing increased concentration of cleaning composition yielded results (Table 3) which clearly indicated that the average charges generated on a glass lens surface were by a factor of 6 smaller for chamois/carbon blacks composite containing sufficient concentration of cleaning composition than for the dry material.

An interesting discharging effect of Lenspen was observed in instances where charges generated by other cleaning media were decreased by 20 to 50% of the initial magnitude after Lenspen was used on the lens surface. The results are presented in Table 6.

This might be a very promising feature indicating a potential possibility of partial removal of accumulated static charges from smooth surface with Lenspen. This effect seems, however, to depend on the sign of the existing electrification, size of the lens, dimension of the tip, chemical structure of the cleaning composition, etc. The experimental results presented in Table 6 were obtained using a Lenspen with an active (cleaning) tip diameter of circa 12mm.

Although the effect is evident it is not clear yet how this effect is related to the electrical properties of the cleaning composition in association with chamois leather. Further experiments would be necessity to clarify this point.

Generation of Electrostatic Charges During Lens Cleaning Procedure

TABLE 1.

Charges measured: ±Q [10- 10 C]

No.	Soft paper	Soft Tissue	Lens Paper	Dry Chamois	Chamois/ Carbon Black
1	- 26	+ 28.1	+27	-16	-2.2
2	- 27	+ 62.8	+16.6	-21.6	-2.3
3	-4.6	+ 56.7	+24.5	-22.8	+0.9
4	-12.1	+62.3	+29.3	-29.9	-1.0
5	-4.8	+ 43.7	+42.6	-23.0	-3.2
6	-6.6	+41.6	+34.7	-33.4	-3.6
7	-28	+39.7	+26.5	-35.6	-2.4
8	-27	+36.3	+38.3	-6.8	-0.9
9	-4.5	+24.8	+11.2	-13.7	-2.3
10	-5.6	+41.2	+18.8	-18.5	-1.9
11	-6.1	+31.8	+8.9	-23.6	-7.6
12	-15.2	+40.5	+22.6	-18.7	-3.6
13	-16.6	+33.2	+12.8	-22.6	-2.1
14	-6.4	+44.6	+17.3	-21.7	-1.5
15	-8.1	+28.5	+24.7	-14.8	-3.1
Average Value	-13.2	+41.0	+23.7	-21.5	-2.6

TABLE 2.

Lens #2 KITSTAR™. Glass; 0 = 58 mm

Charges measured: ±Q [10^{-10} C]

No.	Soft paper	Soft Tissue	Lens Paper	Dry Chamois	Chamois/ Carbon Black
1	+12.4	-1.1	+2.7	+13.5	+2.1
2	+7.7	-7.3	+18.3	+6.8	+0.5
3	+8.1	-3.7	+4.1	+9.8	+3.1
4	+4.9	-6.8	+11.7	+9.2	+2.3
5	+12.4	-14.1	+6.4	+8.6	+6.2
6	+17.1	-1.8	+1.1	+6.4	+12.8
7	+12.2	-2.3	+6.1	+7.2	+5.4
8	+22.6	-4.1	+8.8	+7.3	+7.8
9	+16.5	-3.1	+6.9	+15.7	+3.8
10	+14.3	-2.7	+5.4	+14.3	+1.9
11	+21.6	-2.8	+5.6	+9.8	+5.7
12	+19.6	-2.5	+8.4	+22.3	+3.4
13	+18.2	-4.1	+17.7	+10.4	+7.0
14	+9.8	-8.9	+8.6	+6.8	+5.8
15	+14.7	-2.4	+10.8	+11.3	+2.4
Average Value	+14.1	-4.5	+8.2	+10.6	+4.7

TABLE 3.
Lens #2 KITSTAR™. Glass; 0 = 58 mm
Charges measured: ±Q [10^{-10} C]

No.	Dry Chamois	Chamois/carbon (high surface concentration of carbon)
1	+12.5	+2.5
2	+8.6	+2.6
3	+9.2	+1.2
4	+6.8	+2.8
5	+8.8	+0.5
6	+7.6	+2.1
7	+16.1	+1.8
8	+14.8	+1.2
9	+8.9	+1.5
10	+7.2	+0.5
11	+6.8	+3.1
12	+17.7	+1.3
Average Value	+8.3	+1.4

Average RATIO: dry chamois/chamois+carbon black == 8.3/1.4 = 6.8.

Accumulation of Charges

TABLE 4
Charges measured: ±Q [10-10 C]
Glass lens: KITSTAR™. Glass; 0 = 58 mm | Composite lens: SILOR™; 0=75mm

No.	Dry Chamois	Soft Tissue	Dry Chamois	Soft Tissue
1	+5.5	-4.7	-14.7	+8.1
2	+12.4	-39	-12.0	+12.8
3	+11.8	-33	-21.0	+6.7
4	+11.2	-28.9	-21.6	+13.7
5	+13.8	-25.3	-21.0	+29.3
6	+16.8	-17.6	-27.0	+34.7
7	+22.6	-15.8	-23.0	+42.1
8	+24.3	-21.2	-22.8	+29.7
9	+20.8	-19.6	-28.7	+46.9
10	+23.6	-25.6	-26.1	+43.2

Spontaneous discharge (time dependant decay of the generated charges).

TABLE 5.
Charges measured: ±Q [10-10 C]
Composite lens: KITSTAR™. Glass; 0 = 58 mm | Glass lens: SILOR™; 0=75mm

Time (min)	Dry Chamois	Dry Chamois
1	11.8	9.8
2	7.4	9.1
3	6.3	8.4
4	5.7	7.6
5	5.6	6.8
6	4.5	7.1
7	4.6	6.8
8	4.8	5.9
9	4.7	6.2
10	4.3	5.5

Discharging effect of the Chamois/carbon black composition

TABLE 6.
Charges measured: ±Q [10-10 C]
Composite lens: SILOR™. 0 = 75 mm | Glass lens: KITSTAR™; 0=58mm

No.	Chamois dry	Chamois/Carbon	Chamois dry	Chamois/carbon black
1	-10.7	-4.8	+33.0	+24.0
2	-13.8	-5.6	+29.0	+25.1
3	-16.6	-11.5	+44.5	+31.0
4	-24.2	-16.8	+51.6	+31.2
5	-31.1	-21.6	+54.1	+46.6
6	-34.7	-22.9	+36.4	+29.8
7	-24.6	-16.5	+44.8	+35.7
8	-24.5	21.0	+34.8	+27.6
9	-27.4	-22.0		
10	-30.1	-22.8		

Comment: The Rava device used had a cleaning lip of a diameter of ~12 mm.

ADDENDUM I

Further microscopic observations of the state of lens surface subjected to different cleaning procedures were carried out by Mr. Wojciech (Voytek) Wasak through a Research Department of Parkside Optical Inc.

Richter laboratory microscope with simulated dark field illumination (angle light source) was used to carry out investigation which was documented in a series of microphotographs of the lens surface under 100 magnification.

Glass, polycarbonate and composite material lens elements were used as substrates to canyon a series of additional experiments on effectiveness and safety of Lenspen on various types of coated and uncoated, glass and plastic lens elements.

The observations further confirmed that both the device and the cleaning composition used in the experiments are completely safe to the most delicate lens surface. The effectiveness of the device was also investigated and recorded in a series of microphotographs.

REPRESENTATIVE SAMPLES OF MICROPHOTOGRAPH DOCUMENTATION

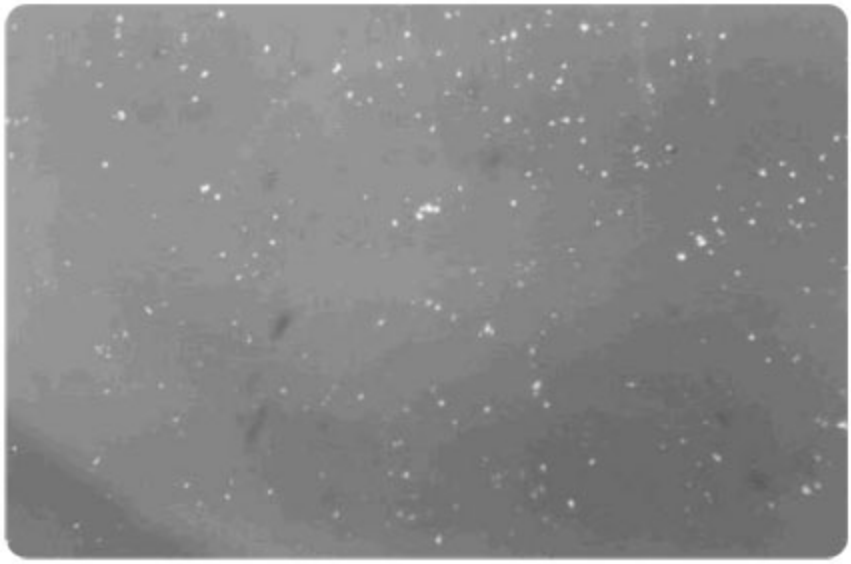
OF COMPARATIVE CLEANING TESTS, JANUARY 5, 1993

SUBSTRATE:
1-9: “ORMA” plastic lens element coated with RF999 antireflection coating.
10-11: Glass lens element coated with multi-layer antireflection coating.

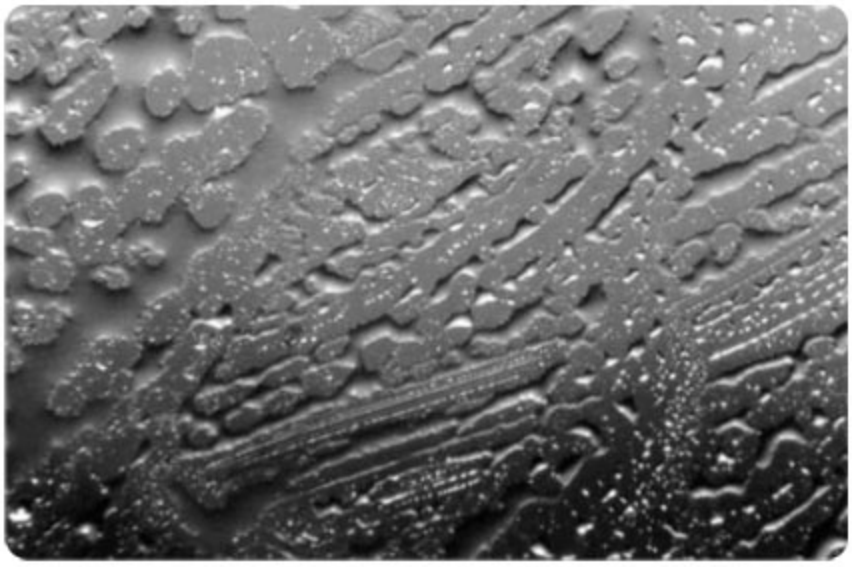
CLEANING MEDIA:
LENSPEN, Lens Cleaning Tissue, Lens Cleaning Cloth.

MAGNIFICATION:
100X

Microphotograph of a clean lens surface

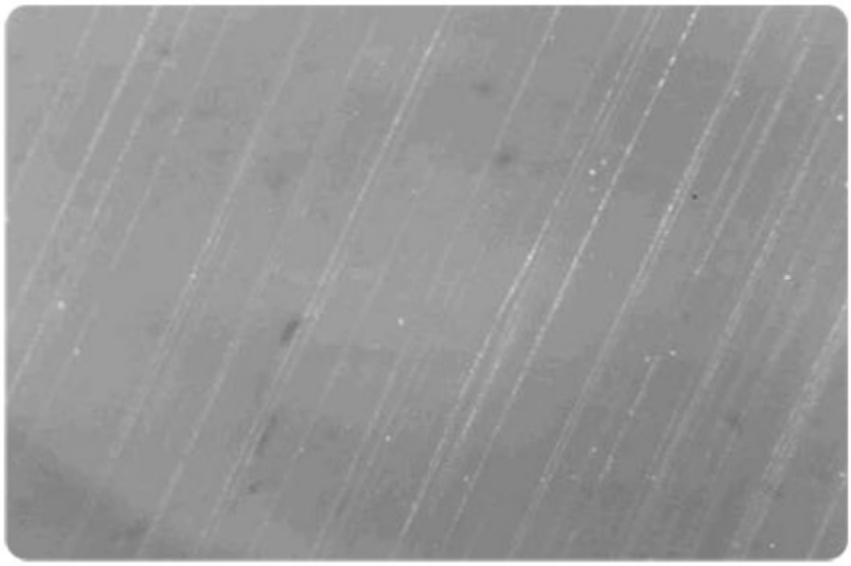


Microphotograph of a lens surface brushed with high quality lens cleaning brush

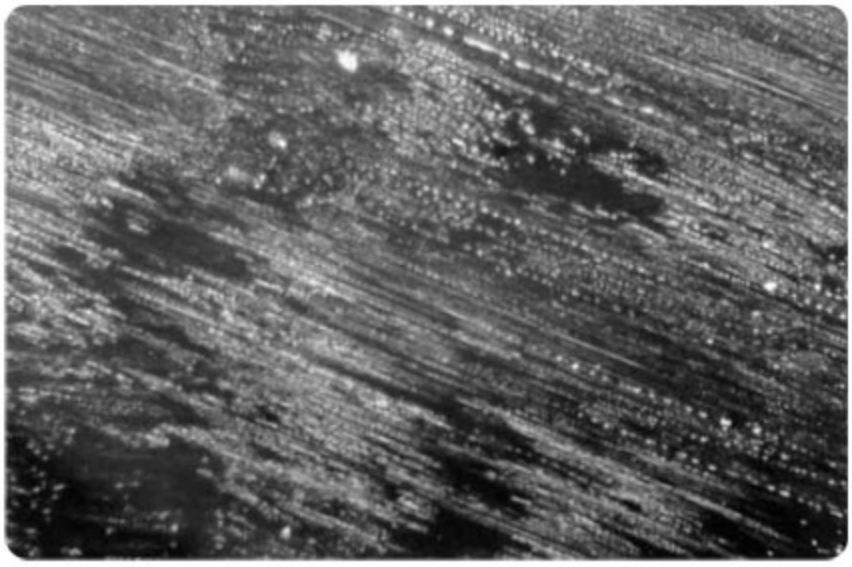


Microphotograph of a lens surface marked with multiple fingerprints, exhibiting high concentration of skin oils

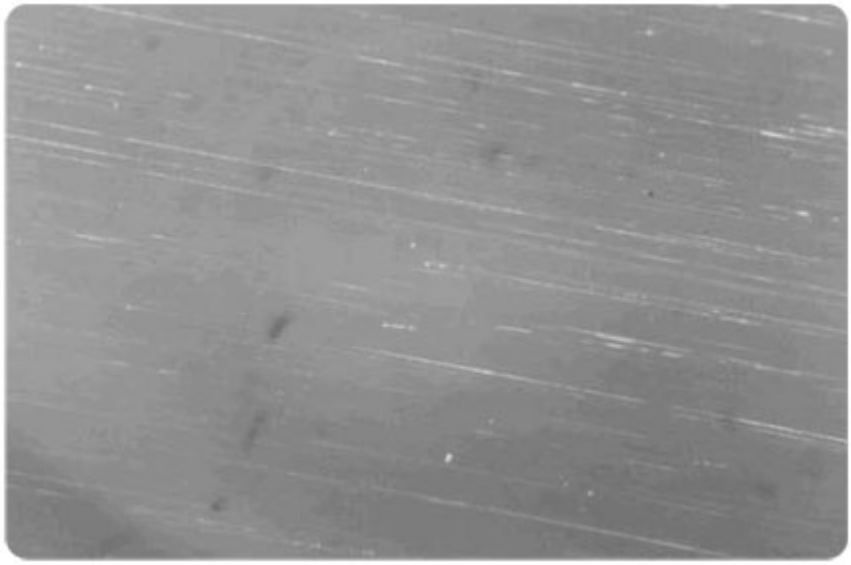
Microphotograph of a lens surface marked with a single fingerprint mark



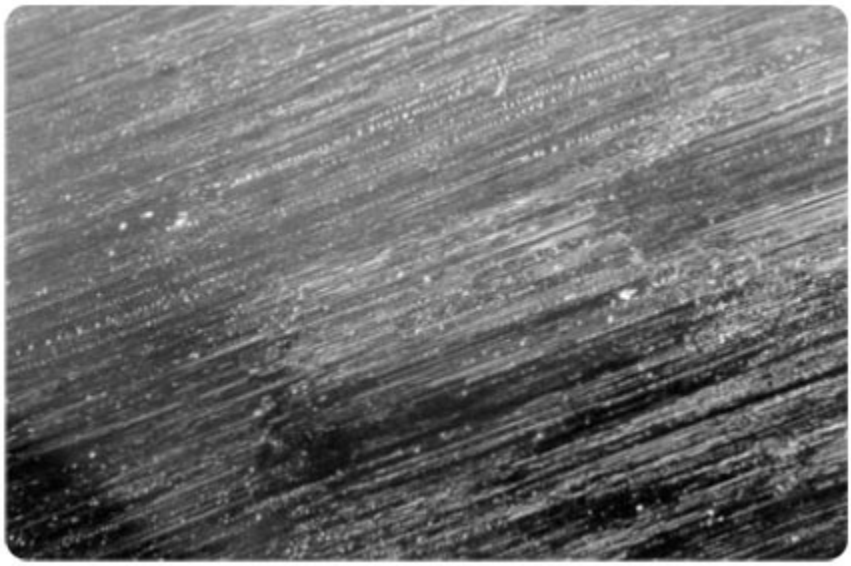
Microphotograph of a lens surface cleaned with a high quality Lens Cleaning Tissue for 10 seconds



Microphotograph of a lens surface marked with a single fingerprint mark

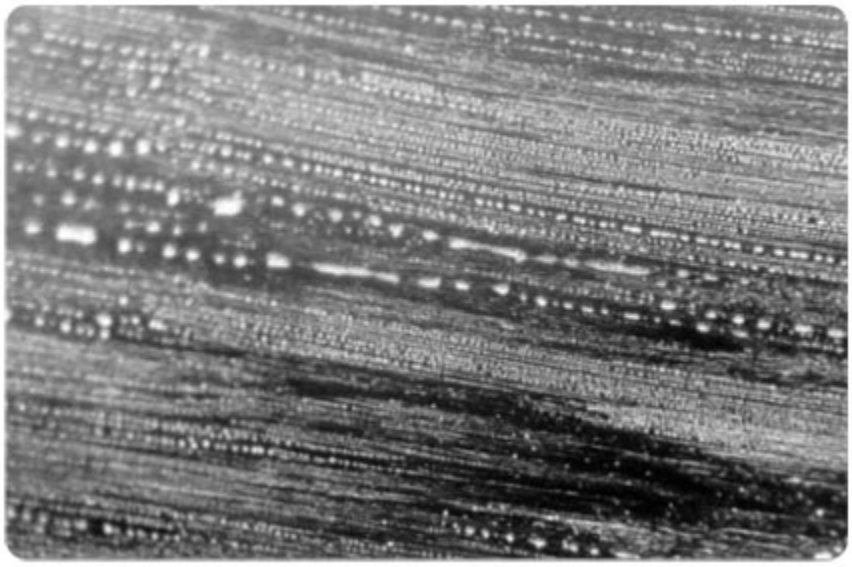


Microphotograph of a lens surface cleaned with a high quality Optical Cloth for 10 seconds



Microphotograph of a lens surface marked with a single fingerprint mark

Microphotograph of a lens surface cleaned with LENSPEN for 10 seconds



Microphotograph of a lens surface marked with multiple fingerprints

Microphotograph of a lens surface cleaned with LENSPEN for 10 seconds