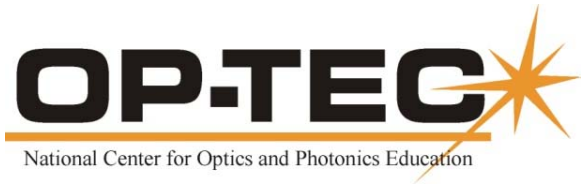
Quality Assurance of Precision Optics

Figures and Images for Instructors

Module 3
Specifications and Drawings for Precision Optics

Precision Optics Series



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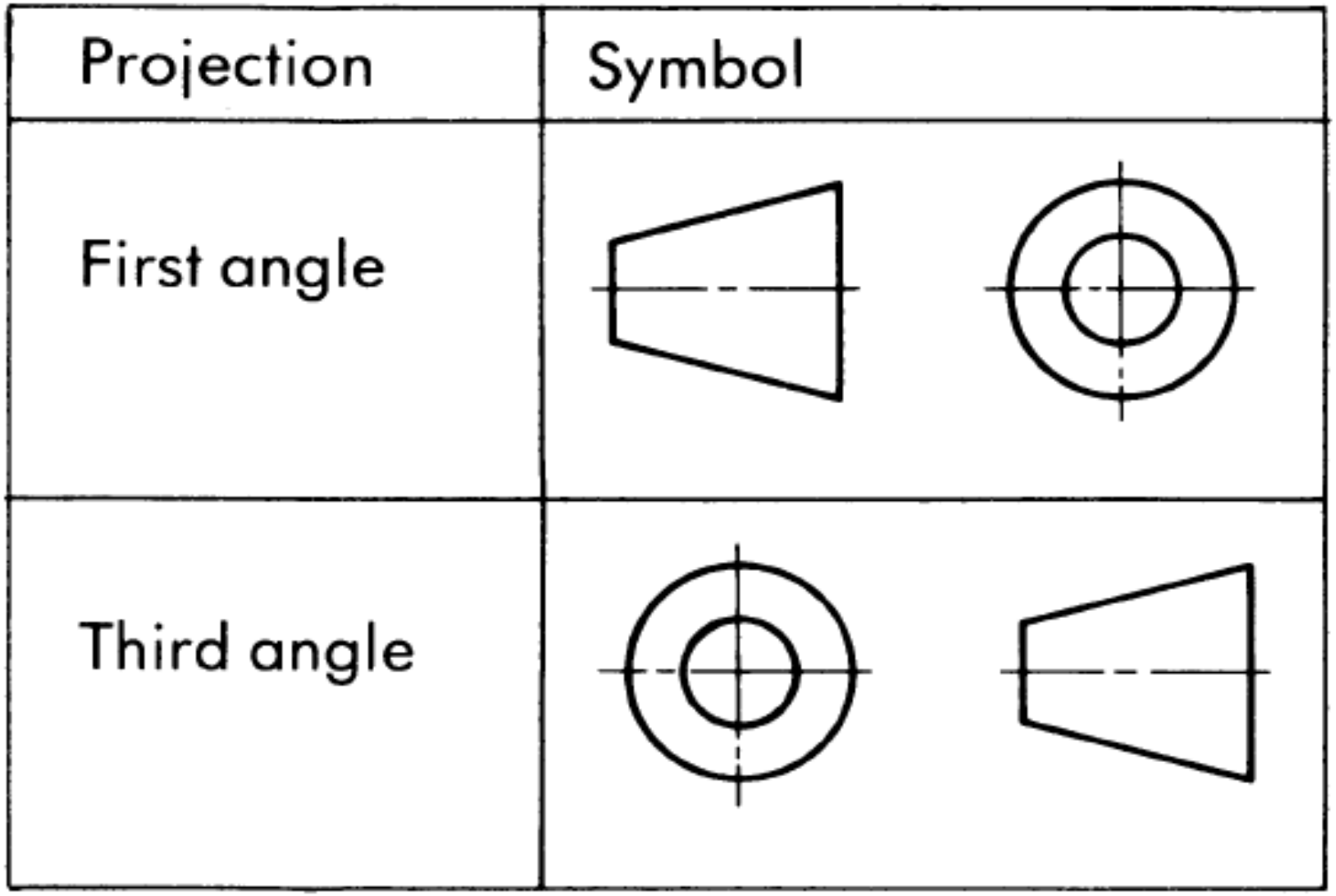
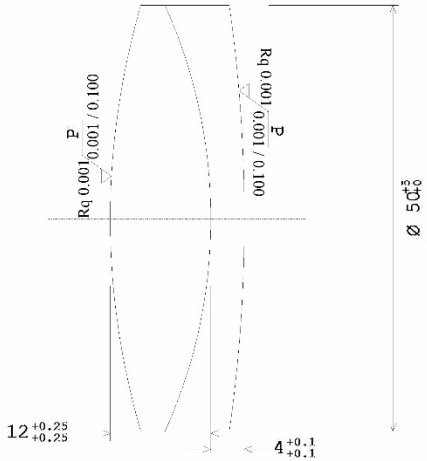


Figure 3-1 *Comparison of the first-angle projection view to the third-angle projection view of the same object*



Dimensions in Millimeters

Left Surface	Material	Middle Surface	Material	Right Surface
R 85 CX	GLASS: N-BAK4	R 60	GLASS: N-SF10	R 175 CX
K -1.5 +0.25 +0.25	N_d= 1.568827 +0.003 +0.003	$Ø_E$ 45 +5 +0	N_d= 1.728277 +0.001 +0.001	$Ø_E$ 45 +5 +0
$Ø_E$ 45 +5 +0	V_d= 55.98 +0.5 +0.1		V_d= 28.53 +0.05 +0.05	Chamfer: 0.25 - 0.75
Chamfer: 0.25 - 0.75	0/ 10	3/ 5(2)	0/ 20	AR 532, 1064
AR 532, 1064	1/ 5x0.1	4/ 0.5 mr (1.7')	1/ 3x0.1	3/ 5(-) RMSi < 1
3/ 5(-) RMSi < 1	2/ 2;4	5/ 3x0.1;L0x0;E0.1	2/ 3;4	4/ 2.0 mr (6.9')
4/ 2.0 mr (6.9')	Note: or S-BAL14	6/ 95;1064;5	Note: or S-TIH10	5/ 5x0.1;C5x0.2;L2x0.01;E0.5
5/ 5x0.1;C5x0.2;L2x0.01;E0.2		Polished: Rq 0.001 0.001/0.100		6/ 95;1064;5
6/ 95;1064;5		Note: bond achromat with NOA63		Note: damage test witness fl
Note: damage test witness flats				

ISO Element Drawing Indications According to ISO 10110

DATE	SCALE	DRAWN	APPRV
2013-07-29	1.3000:1	Monacelli	OP-TEC

PROJECT/TITLE

Quality Assurance of Precision Optics

PART/DRAWING	REVISION
ISO 10110 example	Module 3

ISO 10110 example drawing.zmx
Configuration 1 of 1

Figure 3-2 *ISO 10110 drawing example: doublet lens*

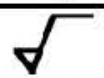
Part	Title	Indication
1	General	N/A
2	Material Imperfections – Stress Birefringence	0/
3	Material Imperfections – Bubbles and Inclusions	1/
4	Material Imperfections – Inhomogeneity and Striae	2/
5	Surface Form Tolerances	3/
6	Centering Tolerances	4/
7	Surface Imperfection Tolerances	5/
8	Surface Texture	
9	Surface Treatment and Coating	
10	Table Representing Data of a Lens Element	N/A
11	Non-toleranced Data	N/A
12	Aspheric Surfaces	N/A
17	Laser Irradiation Damage Threshold	6/

Figure 3-3 *ISO 10110 drawing specification structure*

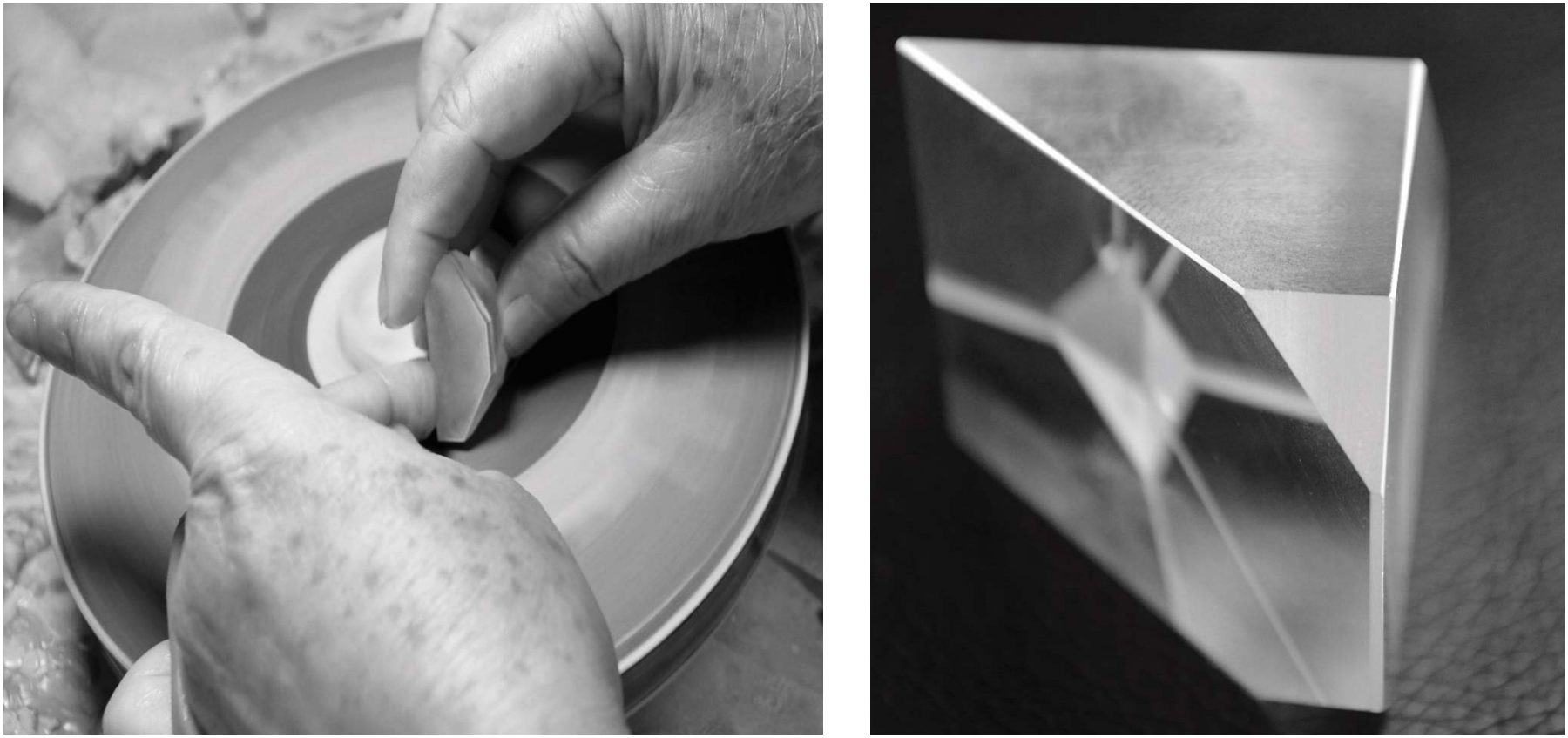


Figure 3-4 *This precision optics technician is adding a chamfer to the edge of a prism. The prism corner in the foreground of the right image has been chamfered*

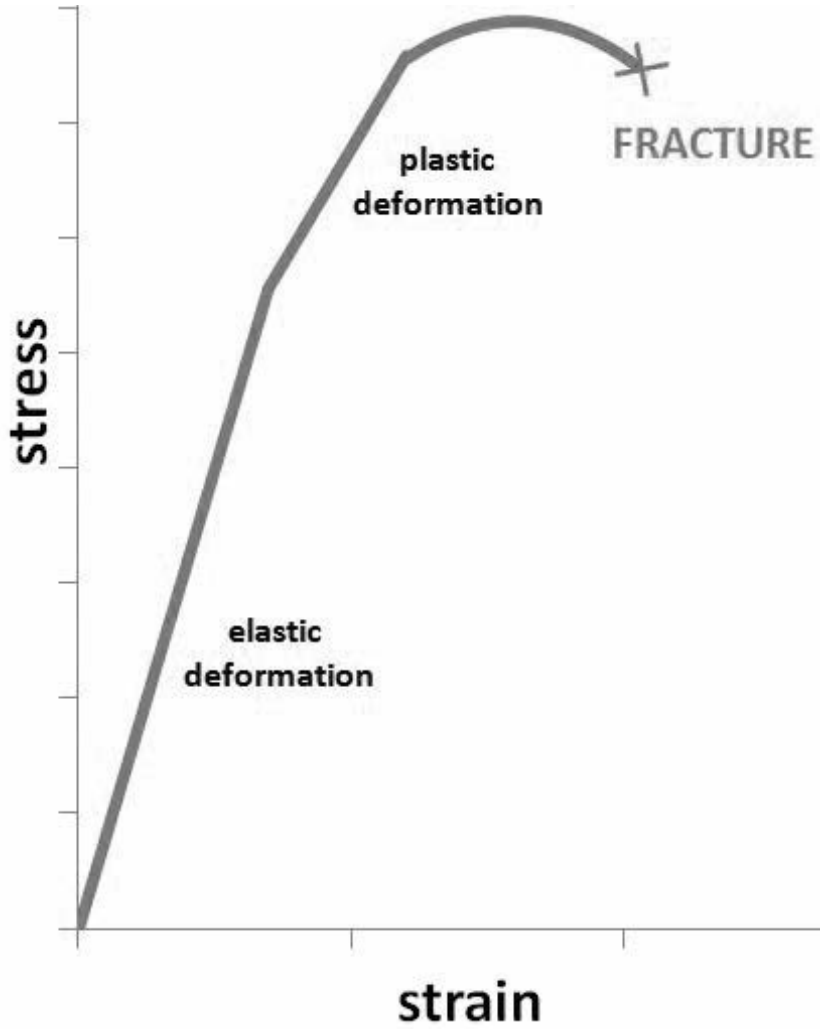


Figure 3-5 *Basic stress–strain curve, showing regions of elastic and plastic deformation as stress is applied, until the material ultimately fractures*

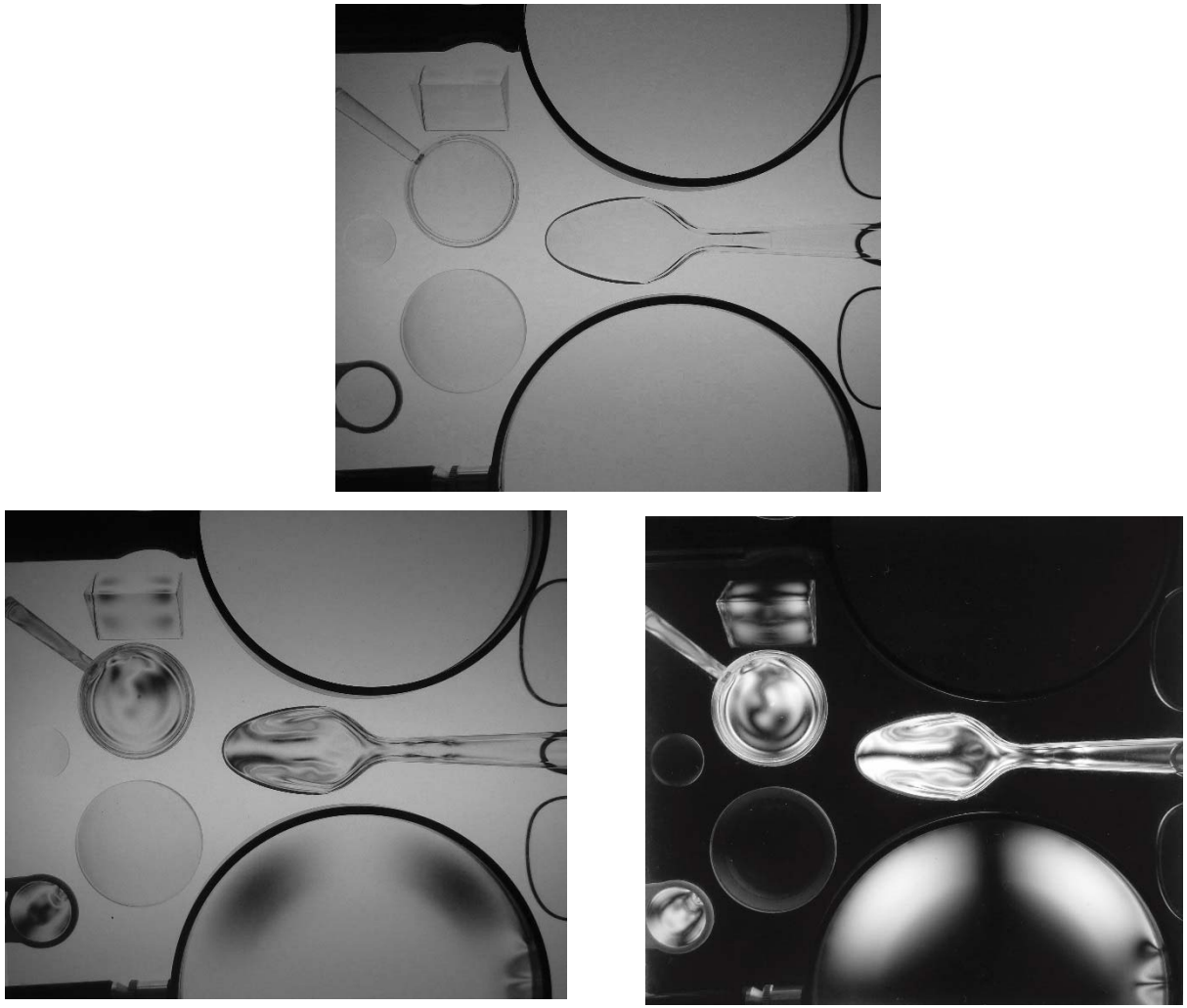


Figure 3-6 *Various optical materials under polarized light*

ISO 10110 indication	permissible OPD per thickness [nm/cm]
0/ 2	2
0/ 4	4
0/ 5	5
0 /10	10
0/ 20	20
0/ -	no requirement

Figure 3-7 *Stress birefringence is given by the indicator 0/ followed by the OPD induced by stress*

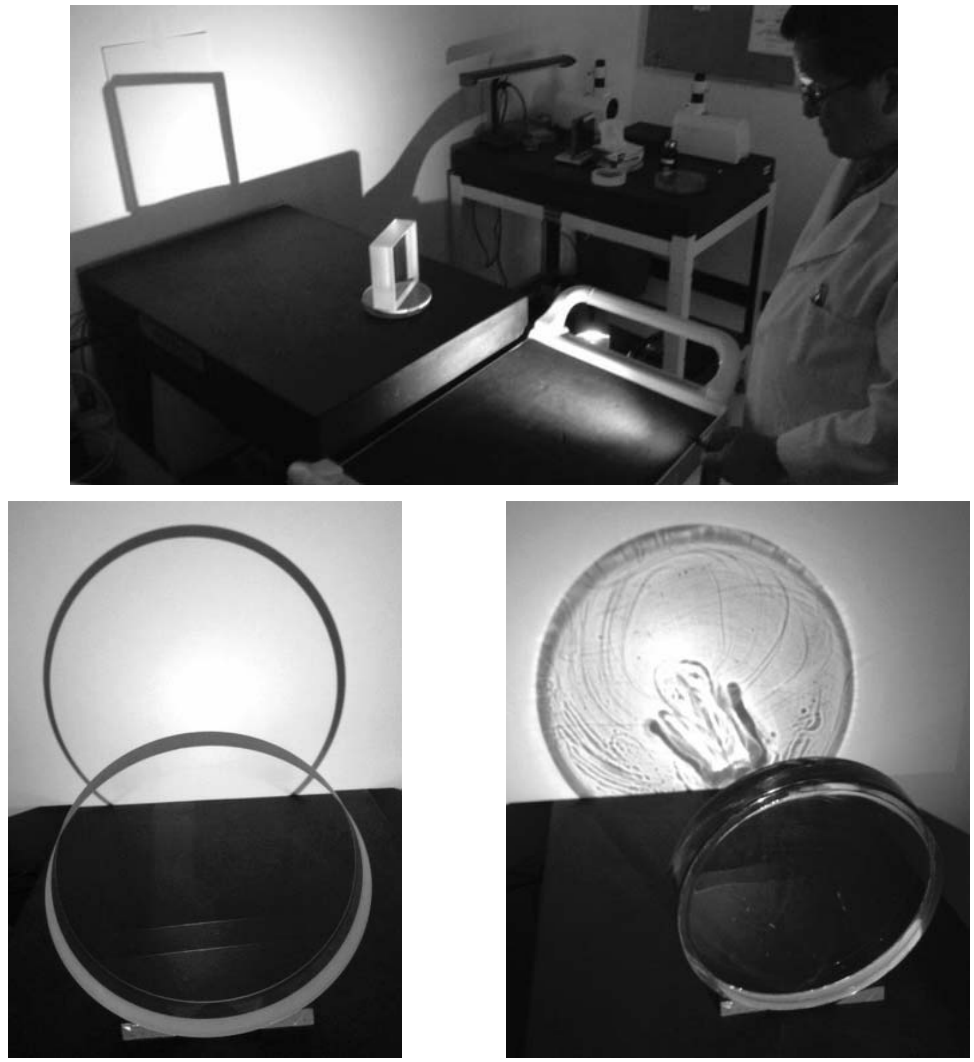


Figure 3-8 *The top image shows a shadowgraph being used in an industrial setting. The lower left image show almost no striae (class 5 / grade A), while the lower right images shows high striae (class 1 / grade D).*

Homogeneity Class	Maximum permissible variation of refractive index
0	$\pm 50 \cdot 10^{-6}$
1	$\pm 20 \cdot 10^{-6}$
2	$\pm 5 \cdot 10^{-6}$
3	$\pm 2 \cdot 10^{-6}$
4	$\pm 1 \cdot 10^{-6}$
5	$\pm 0.5 \cdot 10^{-6}$

Figure 3-9 *Homogeneity Class Standards for Precision Optical Materials, per Standard ISO 10110-4*

Striae Class	Density of striae causing an optical path difference of 30 nm
1	≤ 10%
2	≤ 5%
3	≤ 2%
4	≤ 1%
5	no visible striae

Figure 3-10 *Striae Class Standards for Precision Optical Materials, per Standard ISO 10110-4*

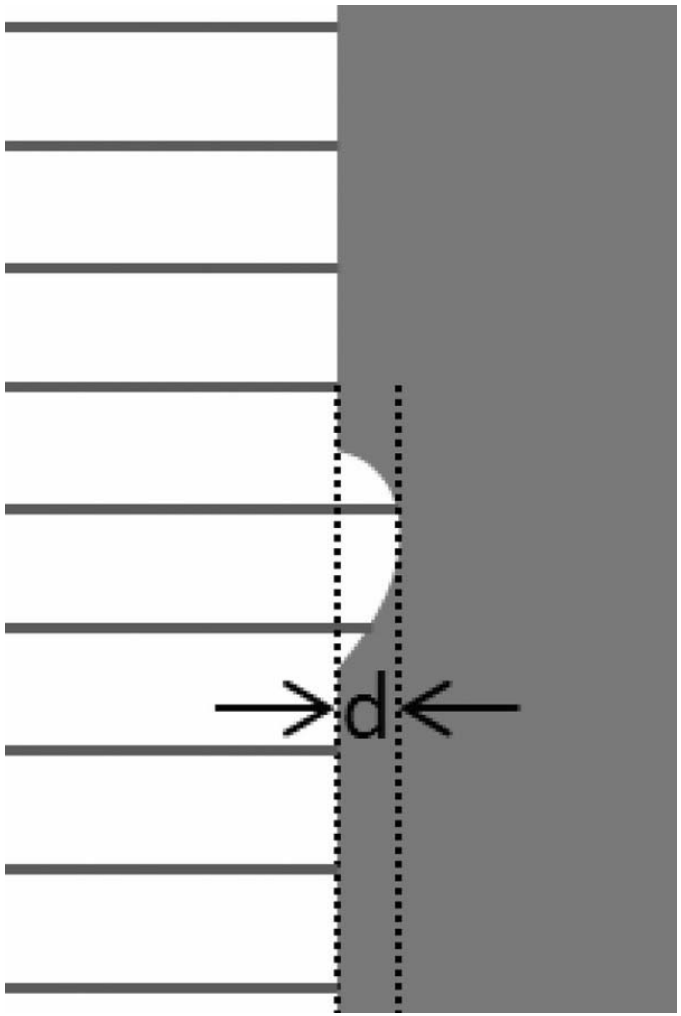


Figure 3-11 *The flat surface in the middle of this figure has an error in it of depth* **d**, *so the light (represented by the lines on the left) will have to travel a distance of* **2d** *when reflected from this surface. This shows that RWFE is twice the surface figure error.*

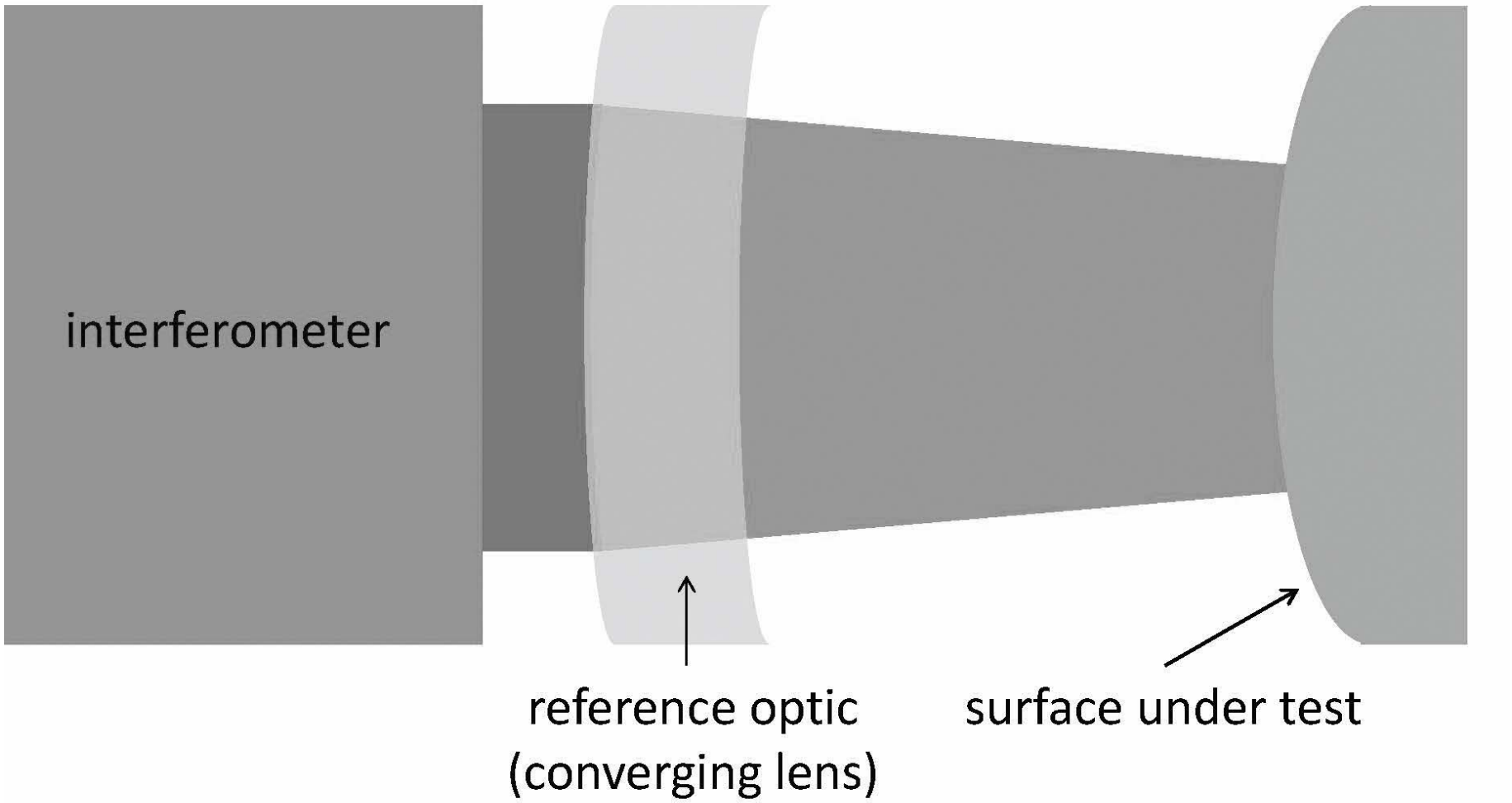


Figure 3-12 *An example of a setup for surface figure or RWFE measurement of a precision optic's convex surface*

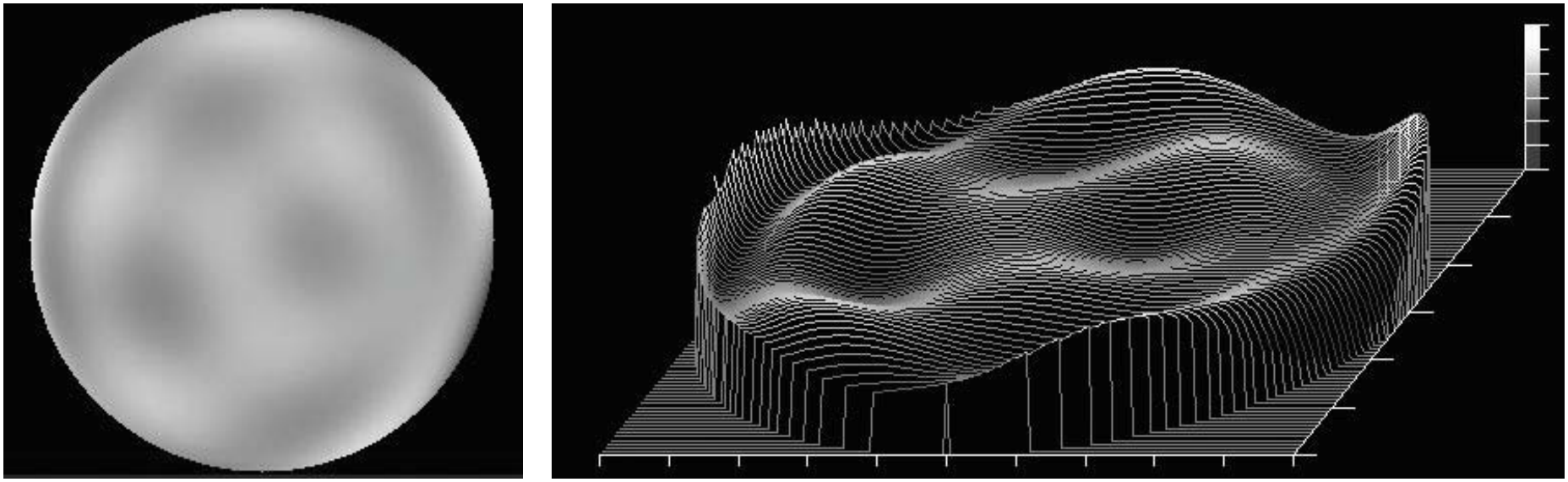


Figure 3-13 *An example of a surface map showing the highs and lows of a precision optical surface, as measured by an interferometer; plan view on the left, isometric view on the right*

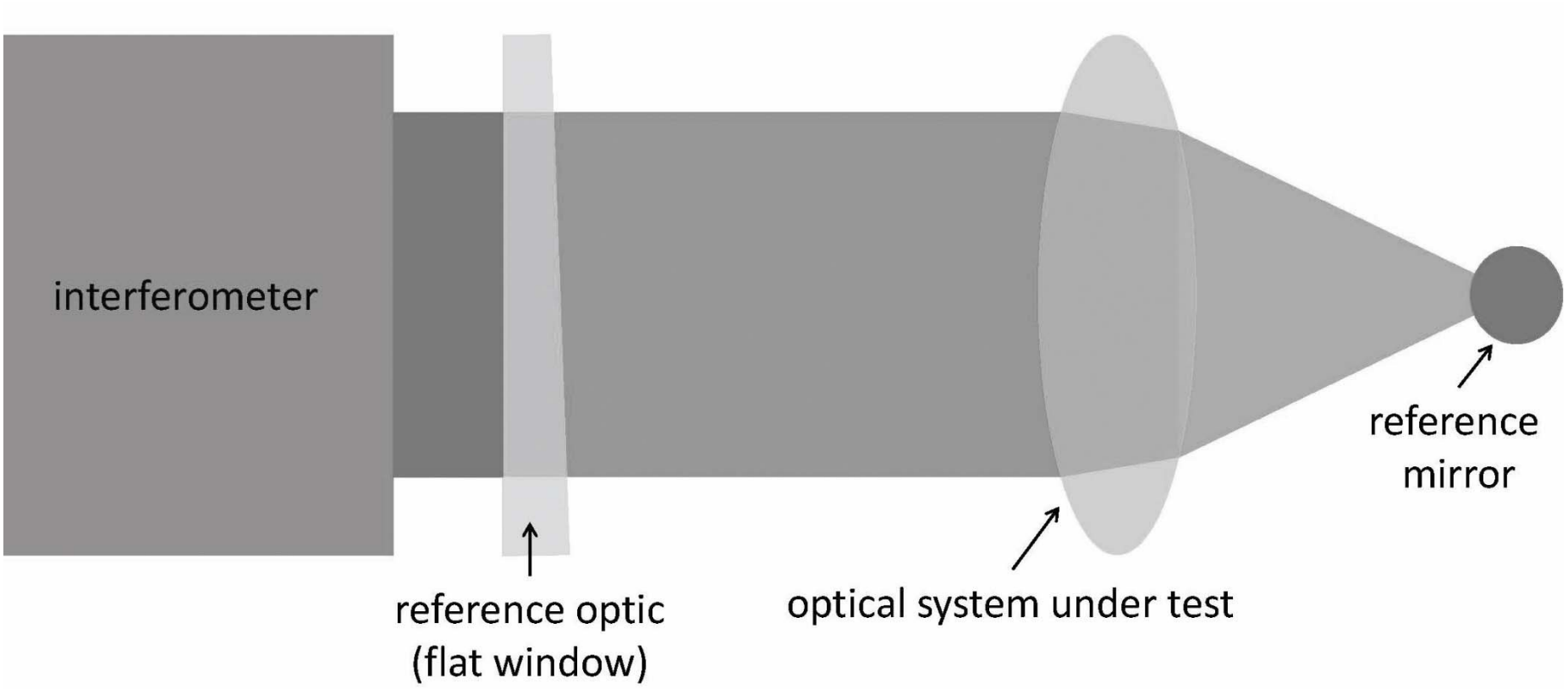


Figure 3-14 *An example of a setup for TWFE measurement of a precision lens or multielement optical system*

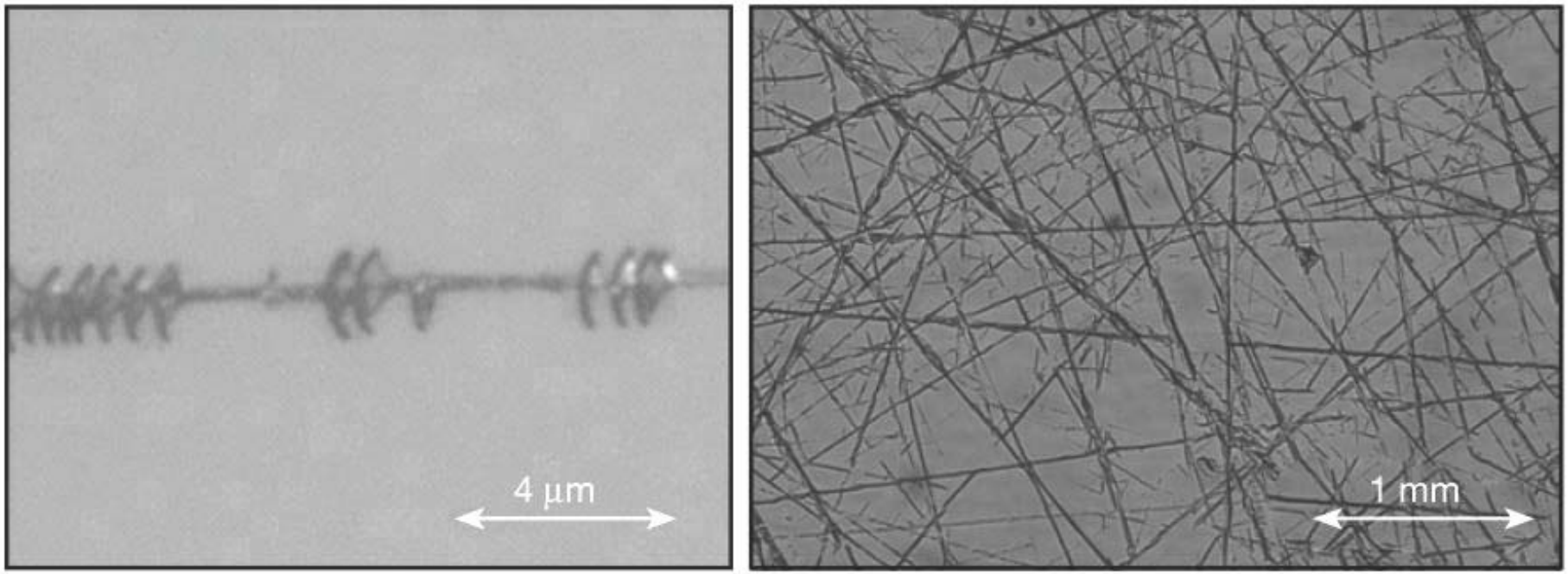


Figure 3-15 *Examples of scratches on precision optics, as seen under microscope inspection*

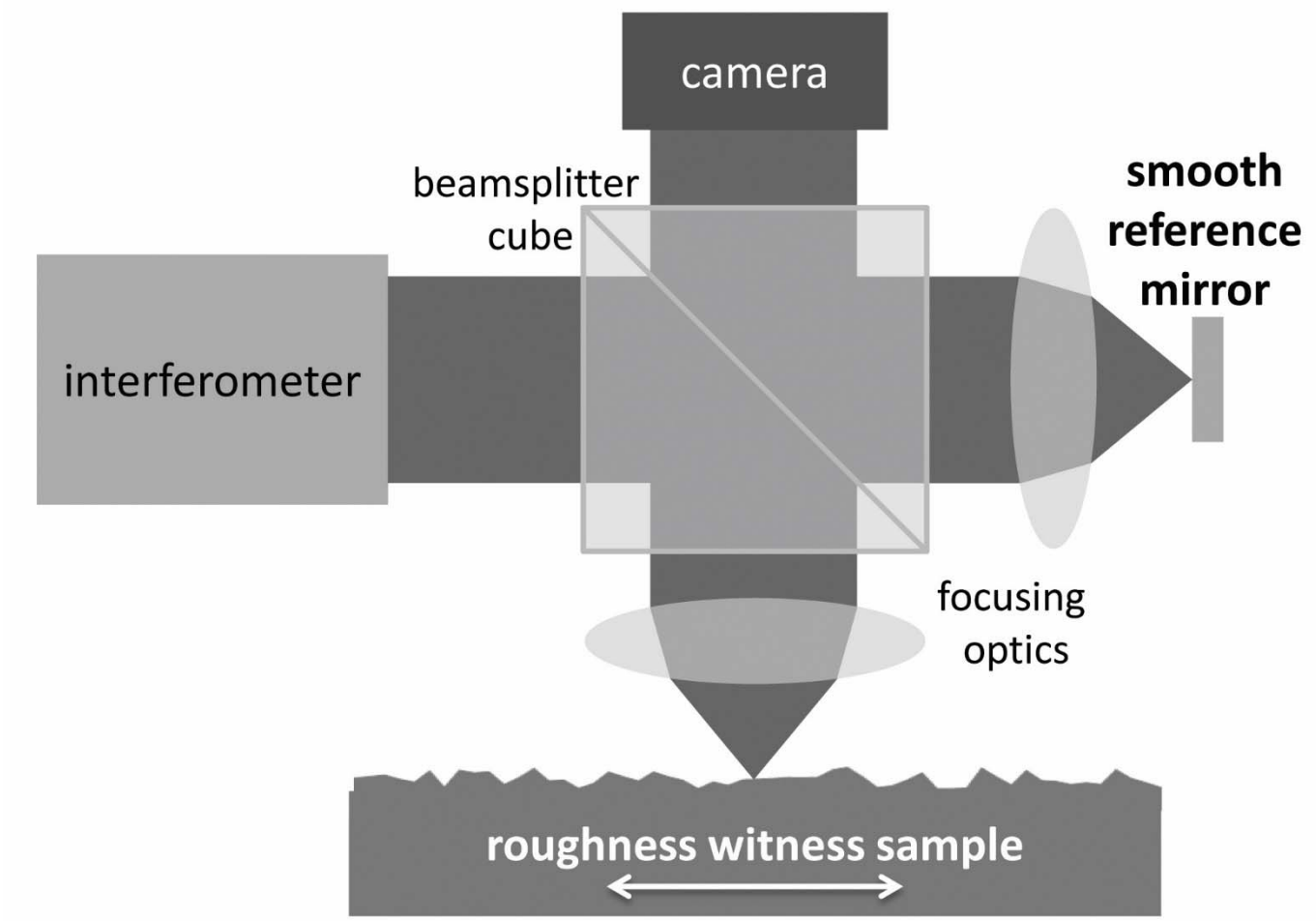


Figure 3-16 *An interferometric and optical profile has two beam paths: one beam measures a smooth reference mirror surface, and the other measures a witness sample surface. The resulting interferogram at each sample point provides a measure of the witness sample roughness.*

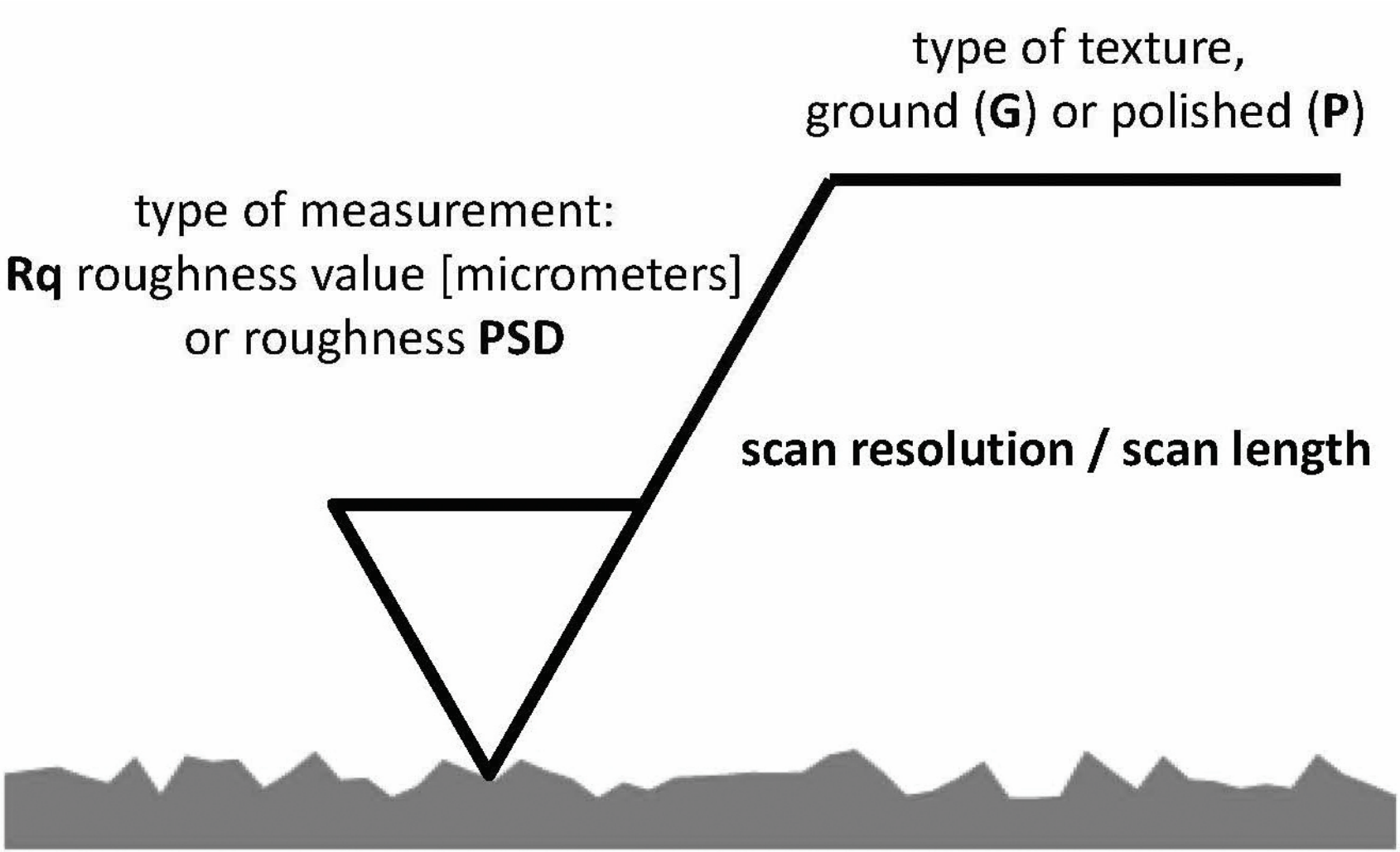


Figure 3-17 *Per ISO 10110-8, this is the indicator for surface texture and its parameters*

Property	Range of maximum (diagonal) dimension of the part [mm]			
	up to 10	10 to 30	30 to 100	100 to 300
Edge length, diameter [mm]	± 0.2	± 0.5	± 1.0	± 1.5
Thickness [mm]	± 0.1	± 0.2	± 0.4	± 0.8
Ange deviaion of prism and plate	± 30'	± 30'	± 30'	± 30'
Width of protective chamfer [mm]	0.1 to 0.3	0.2 to 0.5	0.3 to 0.8	0.5 to 1.6
Stess birefringence [nm/mm] (per ISO 10110-2)	0/ 20	0/ 20	-	-
Bubbles and inclusions (per ISO 10110-3)	1/ 3x0.16	1/ 5x0.25	1/ 5x0.40	1/ 5x0.63
Inhomogeneity and striae (per ISO 10110-4)	2/ 1;1	2/ 1;1	-	-
Surface form tolerances (per ISO 10110-5)	3/ 5(1)	3/ 10(2)	3/ 10(2)	3/ 10(2)
Centering tolerances (per ISO 10110-6)	4/ 30'	4/ 20'	4/ 10'	4/ 10'
Surface imperfection tolerances (per ISO 10110-7)	5/ 3x0.16	5/ 5x0.25	5/ 5x0.40	5/ 5x0.63

Figure 3-18 *ISO 10110-11 drawing specifications for non-toleranced data*

Standard ISO 14644-1	cleanroom class designation		number of particles per cubic meter for each particle size given					
	Metric	English	0.1 micrometer-sized particles	0.2 micrometer-sized particles	0.3 micrometer-sized particles	0.5 micrometer-sized particles	1.0 micrometer-sized particles	5.0 micrometer-sized particles
ISO 1			10	2				
ISO 2			100	24	10	4		
ISO 3	M1.5	1	1,000	237	102	35	8	
ISO 4	M2.5	10	10,000	2,370	1,020	352	83	
ISO 5	M3.5	100	100,000	23,700	10,200	3,520	832	29
ISO 6	M4.5	1,000	1,000,000	237,000	102,000	35,200	8,320	293
ISO 7	M5.5	10,000				352,000	83,200	2,930
ISO 8	M6.5	100,000				3,520,000	832,000	29,300
ISO 9						35,200,000	8,320,000	293,000

Figure 3-19 *Cleanroom Cleanliness Standards for Precision Optics, per ISO Standard 14644-1*

NVR Surface Cleanliness Level	Surface Contaminant Limit [µg/mm^2]
A/100	0.01
A/SO	0.02
A/20	0.05
A/10	0.1
A/S	0.2
A/2	0.5
A	1.0
B	2.0
C	3.0
D	4.0
E	5.0

Figure 3-20 *Cleanliness Standards for Optical Surfaces, per Standard MIL-1246C*

Figure 3-21 *Environmental chambers like these are used to test precision optics by changing the ambient temperature and pressure and by simulating the conditions, such as humidity and salinity, of their application*

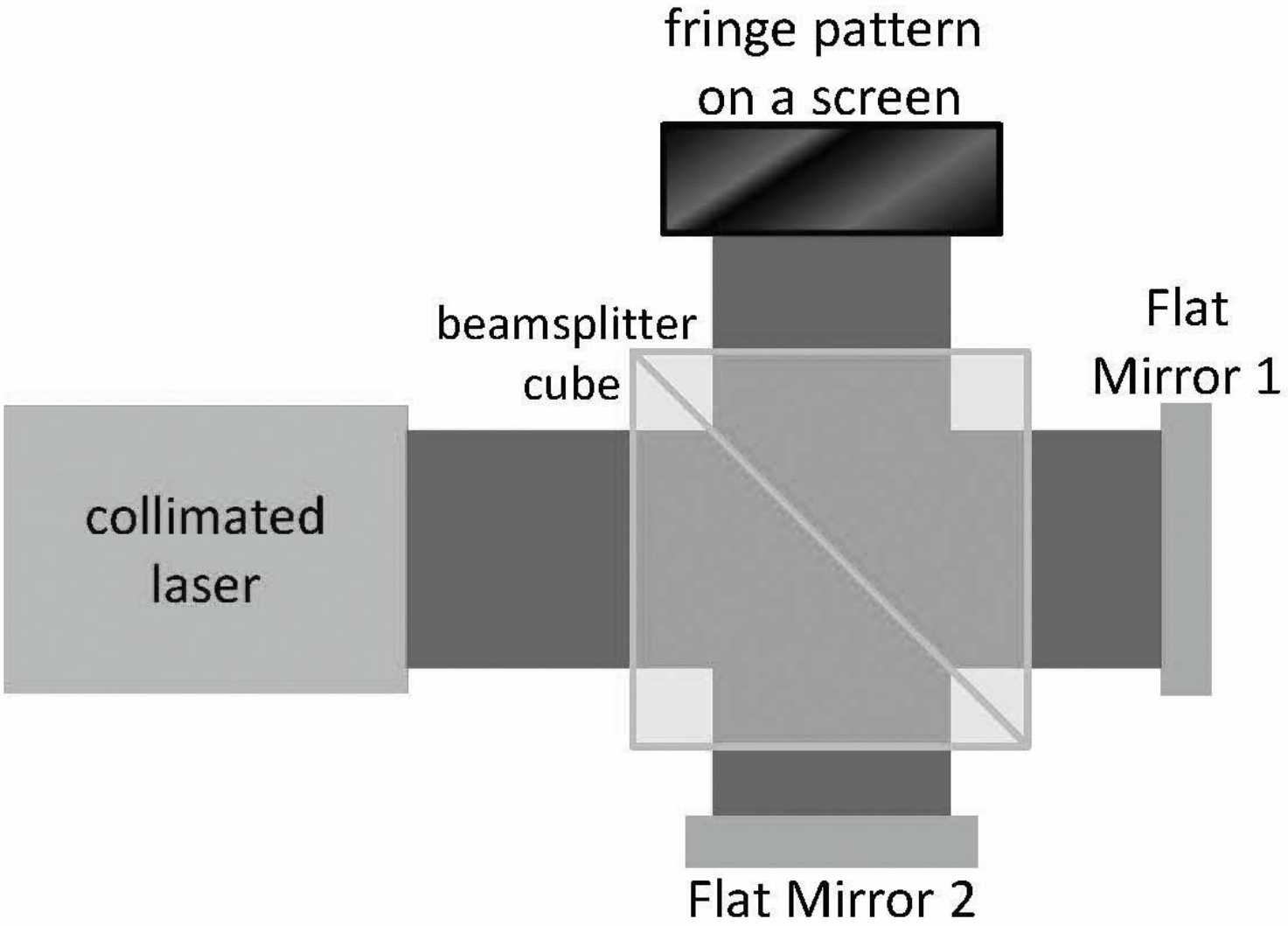


Figure 3-22 *Schematic of an Interferometer*

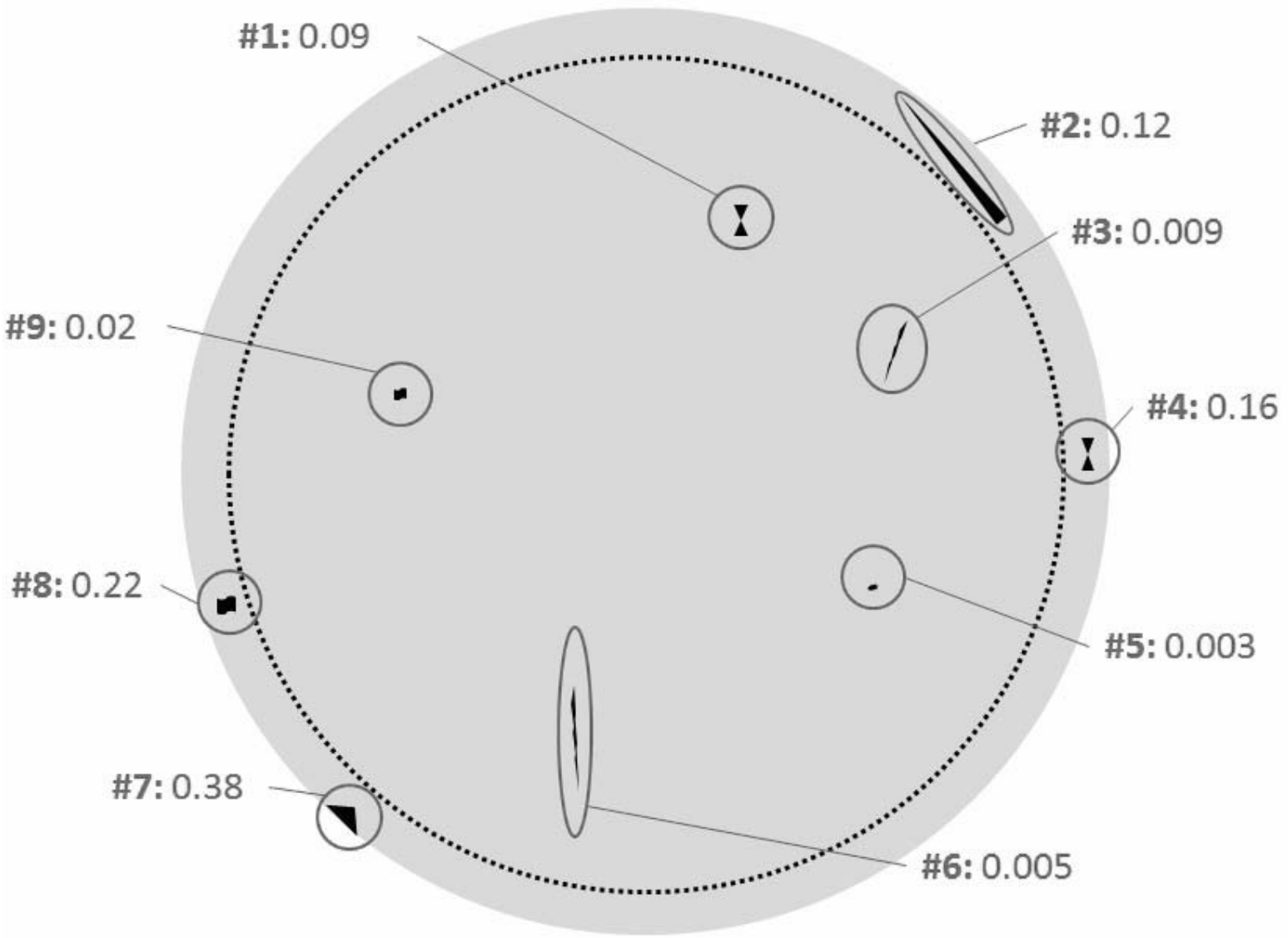


Figure 3-23 *Blemishes found on Substrate Surface Serial #3A*