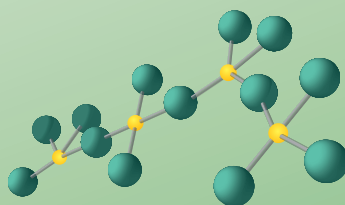




Nikon Synthetic Silica Glass (SiO_2)

NIFS

S e r i e s



NIKON CORPORATION
Industrial Solutions Business Unit

Nikon NIFS Series Synthetic Silica Glass

NIFS Series ADVANTAGES

Nikon's synthetic silica glass (SiO₂) NIFS series is built around over 90 years experience in the field of optics. By combining our critical process controls and leading metrology capabilities, we offer materials which meet and exceed our customers' standard requirements. With our proprietary synthesis and annealing processes, we can optimize our glass to meet our customers' application requirements for homogeneity, birefringence and OH content. The NIFS series is the ideal choice for OEM, R&D and special project requirements for Semiconductor lithography, High - power Nd:YAG, Astronomy, Medical and FPD applications.

Optical grades

Grade	Internal transmittance [%] Sample thickness: 10 mm	Laser durability	Birefringence	Striae	Recommended wavelength
NIFS-V	≥99.9(at 193 nm)	A	1 - 10 nm/cm on request	3D Free	ArF excimer laser (193 nm)
NIFS-A	≥99.9(at 193 nm)	B		3D Free 1D Free	ArF excimer laser (193 nm)
NIFS-U	≥99.9(at 248 nm)	C		3D Free 1D Free	KrF excimer laser (248 nm)
NIFS-S	≥99.9(at 365 nm)	—		3D Free 1D Free	UV region, Visible region
NIFS-I	—	—	—	—	—

※ Values stated above are valid for material with a diameter of 30 - 350 mm and a thickness of 5 - 100 mm. Material outside this range will be regarded as custom.

※ Laser durability is classified into three groups, A, B and C, with NIFS-V represents the highest grade of material available.

※ Material available in Striae 3D Free (all directions) or in the required working direction (1D Free).

NIFS Available range of homogeneity

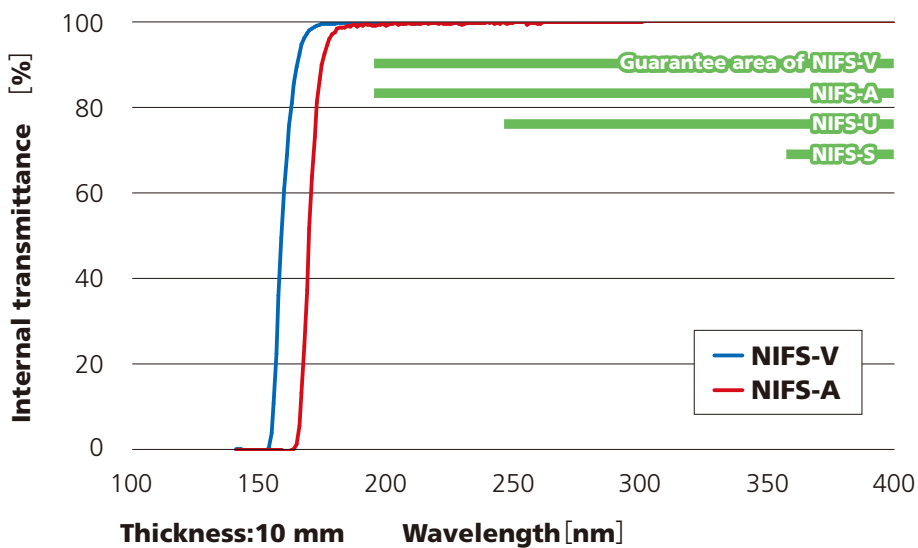
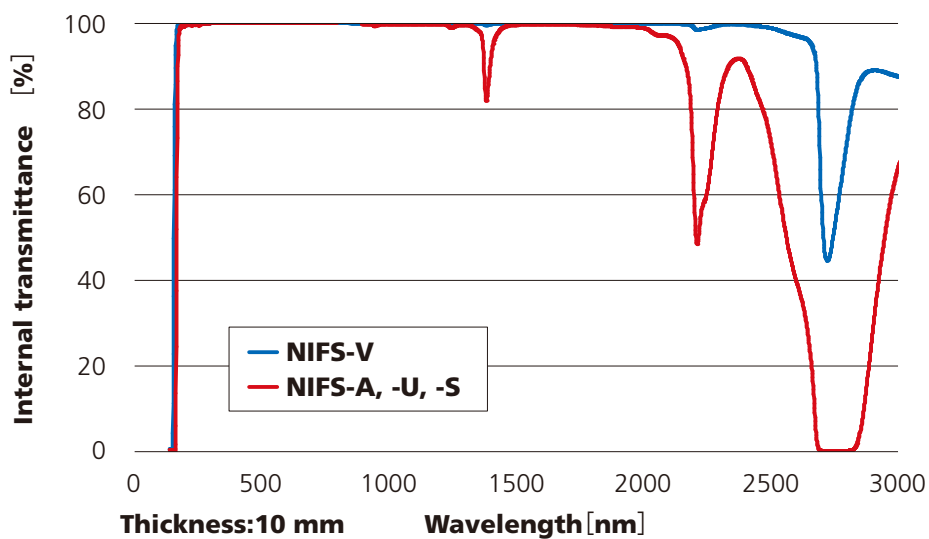
at 633 nm

Homogeneity [ppm]	< 0.5	< 1	< 1.5	< 2	< 3	< 4	< 5	< 10	< 40	Not specified
NIFS-V										
NIFS-A										
NIFS-U										
NIFS-S										

NIFS Transmittance range

F ₂	ArF	KrF	i-line	g-line	
157 nm	193 nm	248 nm	365 nm	436 nm	
					NIFS-V
					NIFS-A
					NIFS-U
					NIFS-S

Transmittance data — VUV-VIS-IR region —



Nikon NIFS Series Synthetic Silica Glass

Properties of NIFS-V (Nikon Synthetic Silica Glass)

n_d	1.45856	v_d	67.86
n_e	1.46018	v_e	67.71

Optical Properties

Wavelength[μm]	Refractive Indices
-	2.32542
-	1.97002
-	1.52958
-	1.0603
t	1.01398
s	0.85211
r	0.70652
C	0.65627
C'	0.64385
He-Ne	0.63280
D	0.58929
d	0.58756
e	0.54608
F	0.48613
F'	0.47999
g	0.43584
h	0.40466
i	0.36502
-	0.33415
-	0.31270
-	0.29673
-	0.2804
KrF	0.2484
-	0.19416
ArF	0.1934
-	0.18489

Conditions:
temperature: 22.5 °C
humidity: 50 %
atmospheric pressure: 1013.25 hPa

Dispersion Coefficients *7	
P ₁	6.40349086E-01
P ₂	3.74308316E-01
P ₃	8.97505390E-02
P ₄	9.08924481E-01
Q ₁	4.25379400E-03
Q ₂	1.27798420E-02
Q ₃	1.40044370E-02
Q ₄	9.93231891E+01

Partial Dispersions	
F - C	0.006758
F' - C'	0.006797

Abnormal Dispersions	
ΔP _{C,t}	0.0387
ΔP _{C,s}	0.0158
ΔP _{F,e}	-0.0017
ΔP _{g,F}	-0.0020
ΔP _{i,g}	0.0059

Relative Partial Dispersions	
P _{s,t}	0.3287
P _{C,s}	0.5769
P _{d,C}	0.3102
P _{e,d}	0.2388
P _{g,F}	0.5277
P _{i,h}	0.7284
P' _{s,t}	0.3268
P' _{C',s}	0.6232
P' _{d,C'}	0.2588
P' _{e,d}	0.2374
P' _{g,F'}	0.4693
P' _{i,h}	0.7243

Constants for Absolute Δn/ΔT *8			
D ₀	2.21E-05	E ₀	2.52E-07
D ₁	3.00E-08	E ₁	4.92E-10
D ₂	-1.14E-12	λ/μm	2.35E-01

Effect of Temperature on Refractive Index			
°C	Absolute Δn/ΔT [10 ⁻⁶ /°C]		
	1060.0 nm	546.23 nm	365.12 nm
-40 ~ -20	7.3	7.7	8.6
+20 ~ +40	8.7	9.2	10.3
+60 ~ +80	9.6	10.2	11.5

Electrical Properties

Dielectric Constant	[21°C]	ε _r	4.0
Dielectric Loss Angle (21°C/1MHz), [°]		φ	89.93
tan δ (δ = 90°-φ)	[21°C/1MHz]	-	13E-4
Electrical Resistivity (20°C)	[Ω•cm]	-	>1E+16

Thermal Properties

Expansion Coefficient	α	0.55
(+25 ~ +100°C) [10 ⁻⁶ /°C]		
(+25 ~ +200°C) [10 ⁻⁶ /°C]		
(+25 ~ +300°C) [10 ⁻⁶ /°C]		
(+25 ~ +600°C) [10 ⁻⁶ /°C]		
Thermal Conductivity (32°C)[W/m•K]	λ	1.31
Specific Heat Capacity [J/g•K]	c	0.79
Thermal Diffusivity [10 ⁻⁷ m²/sec]	κ	8.03

Mechanical Properties

Young's Modulus	[GPa]	E	72
Poisson's Ratio		μ	0.15
Knoop Hardness	[kgf/mm²] *2	HK	521
Abrasion Hardness	*3	A	32
Shear Modulus	[GPa]	G	31
Compressive Strength	[GPa]	-	0.92
Mohs Hardness	*1	-	5-6
Bending Strength	[GPa]*9	-	0.093
Stress Optical Coefficient	[10 ⁻¹² /Pa]	β	3.4
Stress Optical Coefficient (q11-q12) @ 193 nm	[10 ⁻¹² /Pa]	-	2.66

Chemical Properties

Climatic Resistance	[Class] *4	1
CR(S)		
Acid Resistance by Surface Method	[Class]	1
AR(S)		
Acid Resistance by Powder Method	[Class] *5	1
AR(P)		
Phosphate Resistance	[Class] *6	1
PR(S)		

Specific Gravity	2.20
------------------	------

Impurities

OH	< 100 ppm	Al	< 0.2 ppb
Li	< 0.2 ppb	Ti	< 0.2 ppb
Na	< 0.2 ppb	Cr	< 0.2 ppb
K	< 0.2 ppb	Fe	< 0.2 ppb
Mg	< 0.2 ppb	Cu	< 0.2 ppb
Ca	< 0.2 ppb		

※Each property is shown as a typical value.

Properties of NIFS-A (Nikon Synthetic Silica Glass)

n_d	1.45848	v_d	67.83
n_e	1.46009	v_e	67.68

Optical Properties

Wavelength[μm]	Refractive Indices
-	2.32542
-	1.97002
-	1.52958
-	1.0603
t	1.01398
s	0.85211
r	0.70652
C	0.65627
C'	0.64385
He-Ne	0.63280
D	0.58929
d	0.58756
e	0.54608
F	0.48613
F'	0.47999
g	0.43584
h	0.40466
i	0.36502
-	0.33415
-	0.31270
-	0.29673
-	0.2804
KrF	0.2484
-	0.19416
ArF	0.1934
-	0.18489

Conditions:
temperature: 22.5 °C
humidity: 50 %
atmospheric pressure: 1013.25 hPa

Dispersion Coefficients *7	
P ₁	5.65169763E-01
P ₂	4.22092787E-01
P ₃	1.16894650E-01
P ₄	8.83720207E-01
Q ₁	3.82315600E-03
Q ₂	1.14444180E-02
Q ₃	1.51697040E-02
Q ₄	9.64254081E+01

Partial Dispersions	
F - C	0.006760
F' - C'	0.006799

Abnormal Dispersions	
ΔP _{c,t}	0.0392
ΔP _{c,s}	0.0160
ΔP _{f,e}	-0.0017
ΔP _{g,f}	-0.0021
ΔP _{i,g}	0.0055

Relative Partial Dispersions	
P _{s,t}	0.3289
P _{c,s}	0.5770
P _{d,c}	0.3102
P _{e,d}	0.2388
P _{g,f}	0.5277
P _{i,h}	0.7284
P' _{s,t}	0.3270
P' _{c,s}	0.6234
P' _{d,c}	0.2588
P' _{e,d}	0.2374
P' _{g,f}	0.4693
P' _{i,h}	0.7242

Constants for Absolute Δn/ΔT *8			
D ₀	2.15E-05	E ₀	3.33E-07
D ₁	3.84E-08	E ₁	3.98E-10
D ₂	-5.68E-13	λ/μm	1.84E-01

Effect of Temperature on Refractive Index			
°C	Absolute Δn/ΔT [10 ⁻⁶ /°C]		
	1060.0 nm	546.23 nm	365.12 nm
-40 ~ -20	6.7	7.2	8.1
+20 ~ +40	8.5	9.1	10.2
+60 ~ +80	9.7	10.3	11.5

Electrical Properties

Dielectric Constant	[21 °C]	ε _r	4.0
Dielectric Loss Angle (21 °C/1MHz), [°]		φ	89.93
tan δ (δ = 90° - φ)	[21 °C/1MHz]	-	12E-4
Electrical Resistivity (20 °C)	[Ω·cm]	-	>1E+16

Thermal Properties

Softening Point (logη = 7.6)	[°C] *1	-	1600
Annealing Point (logη = 13.0)	[°C] *1	-	1100
Strain Point (logη = 14.5)	[°C] *1	-	1000
Expansion Coefficient			
(+25 ~ +100 °C)	[10 ⁻⁶ /°C]	α	0.57
(+25 ~ +200 °C)	[10 ⁻⁶ /°C]		0.64
(+25 ~ +300 °C)	[10 ⁻⁶ /°C]		0.63
(+25 ~ +600 °C)	[10 ⁻⁶ /°C]		0.55
Thermal Conductivity (32 °C)	[W/m·K]	λ	1.33
Specific Heat Capacity	[J/g·K]	c	0.79
Thermal Diffusivity	[10 ⁻⁷ m²/sec]	κ	8.17

Mechanical Properties

Young's Modulus	[GPa]	E	71
Poisson's Ratio		μ	0.15
Knoop Hardness	[kgf/mm²] *2	HK	510
Abrasion Hardness	*3	A	40
Shear Modulus	[GPa]	G	31
Compressive Strength	[GPa]	-	0.85
Mohs Hardness	*1	-	5-6
Bending Strength	[GPa] *9	-	0.089
Stress Optical Coefficient	[10 ⁻¹² /Pa]	β	3.3
Stress Optical Coefficient (q11-q12) @ 193 nm	[10 ⁻¹² /Pa]	-	2.65

Chemical Properties

Climatic Resistance			
CR(S)	[Class] *4		1
Acid Resistance by Surface Method			
AR(S)	[Class]		1
Acid Resistance by Powder Method			
AR(P)	[Class] *5		1
Phosphate Resistance			
PR(S)	[Class] *6		1

Specific Gravity	2.20
------------------	------

Impurities

OH	< 1200 ppm	Al	< 0.2 ppb
Li	< 0.2 ppb	Ti	< 0.2 ppb
Na	< 0.2 ppb	Cr	< 0.2 ppb
K	< 0.2 ppb	Fe	< 0.2 ppb
Mg	< 0.2 ppb	Cu	< 0.2 ppb
Ca	< 0.2 ppb		

*Each property is shown as a typical value.

Nikon NIFS Series Synthetic Silica Glass

Properties of NIFS-U (Nikon Synthetic Silica Glass)

n_d	1.45848	v_d	67.83
n_e	1.46009	v_e	67.68

Optical Properties

Wavelength[μm]	Refractive Indices
-	2.32542
-	1.97002
-	1.52958
-	1.0603
t	1.01398
s	0.85211
r	0.70652
C	0.65627
C'	0.64385
He-Ne	0.63280
D	0.58929
d	0.58756
e	0.54608
F	0.48613
F'	0.47999
g	0.43584
h	0.40466
i	0.36502
-	0.33415
-	0.31270
-	0.29673
-	0.2804
KrF	0.2484
-	0.19416
ArF	0.1934
-	0.18489

Conditions:
temperature: 22.5 °C
humidity: 50 %
atmospheric pressure: 1013.25 hPa

Dispersion Coefficients *7	
P ₁	5.65169763E-01
P ₂	4.22092787E-01
P ₃	1.16894650E-01
P ₄	8.83720207E-01
Q ₁	3.82315600E-03
Q ₂	1.14444180E-02
Q ₃	1.51697040E-02
Q ₄	9.64254081E+01

Partial Dispersions	
F - C	0.006760
F' - C'	0.006799

Abnormal Dispersions	
ΔP _{C,t}	0.0392
ΔP _{C,s}	0.0160
ΔP _{F,e}	-0.0017
ΔP _{g,F}	-0.0021
ΔP _{i,g}	0.0055

Relative Partial Dispersions	
P _{s,t}	0.3289
P _{C,s}	0.5770
P _{d,C}	0.3102
P _{e,d}	0.2388
P _{g,F}	0.5277
P _{i,h}	0.7284
P' _{s,t}	0.3270
P' _{C',s}	0.6234
P' _{d,C'}	0.2588
P' _{e,d}	0.2374
P' _{g,F'}	0.4693
P' _{i,h}	0.7242

Constants for Absolute Δn/ΔT *8			
D ₀	2.15E-05	E ₀	3.33E-07
D ₁	3.84E-08	E ₁	3.98E-10
D ₂	-5.68E-13	λ/μm	1.84E-01

Effect of Temperature on Refractive Index			
°C	Absolute Δn/ΔT [10 ⁻⁶ /°C]		
	1060.0 nm	546.23 nm	365.12 nm
-40 ~ -20	6.7	7.2	8.1
+20 ~ +40	8.5	9.1	10.2
+60 ~ +80	9.7	10.3	11.5

Electrical Properties

Dielectric Constant	[21°C]	ε _r	4.0
Dielectric Loss Angle (21°C/1MHz), [°]		φ	89.93
tan δ (δ = 90° - φ)	[21°C/1MHz]	-	12E-4
Electrical Resistivity (20°C)	[Ω•cm]	-	>1E+16

Thermal Properties

Softening Point (logη = 7.6)	[°C] *1	-	1600
Annealing Point (logη = 13.0)	[°C] *1	-	1100
Strain Point (logη = 14.5)	[°C] *1	-	1000
Expansion Coefficient		α	
(+25 ~ +100°C)	[10 ⁻⁶ /°C]		0.57
(+25 ~ +200°C)	[10 ⁻⁶ /°C]		0.64
(+25 ~ +300°C)	[10 ⁻⁶ /°C]		0.63
(+25 ~ +600°C)	[10 ⁻⁶ /°C]		0.55
Thermal Conductivity (32°C)	[W/m•K]	λ	1.33
Specific Heat Capacity	[J/g•K]	c	0.79
Thermal Diffusivity	[10 ⁻⁷ m²/sec]	κ	8.17

Mechanical Properties

Young's Modulus	[GPa]	E	71
Poisson's Ratio		μ	0.15
Knoop Hardness	[kgf/mm²] *2	HK	510
Abrasion Hardness	*3	A	40
Shear Modulus	[GPa]	G	31
Compressive Strength	[GPa]	-	0.85
Mohs Hardness	*1	-	5-6
Bending Strength	[GPa] *9	-	0.089
Stress Optical Coefficient	[10 ⁻¹² /Pa]	β	3.3
Stress Optical Coefficient (q11-q12) @ 193 nm	[10 ⁻¹² /Pa]	-	2.65

Chemical Properties

Climatic Resistance		1
CR(S)	[Class] *4	
Acid Resistance by Surface Method		1
AR(S)	[Class]	
Acid Resistance by Powder Method		1
AR(P)	[Class] *5	
Phosphate Resistance		1
PR(S)	[Class] *6	

Specific Gravity	2.20
------------------	------

Impurities

OH	< 1200 ppm	Al	< 50 ppb
Li	< 50 ppb	Ti	< 50 ppb
Na	< 50 ppb	Cr	< 50 ppb
K	< 50 ppb	Fe	< 50 ppb
Mg	< 50 ppb	Cu	< 50 ppb
Ca	< 50 ppb		

※Each property is shown as a typical value.

Properties of NIFS-S (Nikon Synthetic Silica Glass)

n_d	1.45848	v_d	67.83
n_e	1.46009	v_e	67.68

Optical Properties

Wavelength[μm]	Refractive Indices
-	2.32542
-	1.97002
-	1.52958
-	1.0603
t	1.01398
s	0.85211
r	0.70652
C	0.65627
C'	0.64385
He-Ne	0.63280
D	0.58929
d	0.58756
e	0.54608
F	0.48613
F'	0.47999
g	0.43584
h	0.40466
i	0.36502
-	0.33415
-	0.31270
-	0.29673
-	0.2804
KrF	0.2484
-	0.19416
ArF	0.1934
-	0.18489

Conditions:
temperature: 22.5 °C
humidity: 50 %
atmospheric pressure: 1013.25 hPa

Dispersion Coefficients *7	
P ₁	5.65169763E-01
P ₂	4.22092787E-01
P ₃	1.16894650E-01
P ₄	8.83720207E-01
Q ₁	3.82315600E-03
Q ₂	1.14444180E-02
Q ₃	1.51697040E-02
Q ₄	9.64254081E+01

Partial Dispersions	
F - C	0.006760
F' - C'	0.006799

Abnormal Dispersions	
ΔP _{C,t}	0.0392
ΔP _{C,s}	0.0160
ΔP _{F,e}	-0.0017
ΔP _{g,F}	-0.0021
ΔP _{i,g}	0.0055

Relative Partial Dispersions	
P _{s,t}	0.3289
P _{C,s}	0.5770
P _{d,C}	0.3102
P _{e,d}	0.2388
P _{g,F}	0.5277
P _{i,h}	0.7284
P' _{s,t}	0.3270
P' _{C',s}	0.6234
P' _{d,C'}	0.2588
P' _{e,d}	0.2374
P' _{g,F'}	0.4693
P' _{i,h}	0.7242

Constants for Absolute Δn/ΔT *8			
D ₀	2.15E-05	E ₀	3.33E-07
D ₁	3.84E-08	E ₁	3.98E-10
D ₂	-5.68E-13	λ/μm	1.84E-01

Effect of Temperature on Refractive Index			
°C	Absolute Δn/ΔT [10 ⁻⁶ /°C]		
	1060.0 nm	546.23 nm	365.12 nm
-40 ~ -20	6.7	7.2	8.1
+20 ~ +40	8.5	9.1	10.2
+60 ~ +80	9.7	10.3	11.5

Electrical Properties

Dielectric Constant	[21 °C]	ε _r	4.0
Dielectric Loss Angle (21 °C/1MHz), [°]		φ	89.93
tan δ (δ = 90° - φ)	[21 °C/1MHz]	-	12E-4
Electrical Resistivity (20 °C)	[Ω·cm]	-	>1E+16

Thermal Properties

Softening Point (log η = 7.6)	[°C] *1	-	1600
Annealing Point (log η = 13.0)	[°C] *1	-	1100
Strain Point (log η = 14.5)	[°C] *1	-	1000
Expansion Coefficient			
(+25 ~ +100 °C)	[10 ⁻⁶ /°C]	α	0.57
(+25 ~ +200 °C)	[10 ⁻⁶ /°C]		0.64
(+25 ~ +300 °C)	[10 ⁻⁶ /°C]		0.63
(+25 ~ +600 °C)	[10 ⁻⁶ /°C]		0.55
Thermal Conductivity (32 °C)	[W/m·K]	λ	1.33
Specific Heat Capacity	[J/g·K]	c	0.79
Thermal Diffusivity	[10 ⁻⁷ m²/sec]	κ	8.17

Mechanical Properties

Young's Modulus	[GPa]	E	71
Poisson's Ratio		μ	0.15
Knoop Hardness	[kgf/mm²] *2	HK	510
Abrasion Hardness	*3	A	40
Shear Modulus	[GPa]	G	31
Compressive Strength	[GPa]	-	0.85
Mohs Hardness	*1	-	5-6
Bending Strength	[GPa] *9	-	0.089
Stress Optical Coefficient	[10 ⁻¹² /Pa]	β	3.3
Stress Optical Coefficient (q11-q12) @ 193 nm	[10 ⁻¹² /Pa]	-	2.65

Chemical Properties

Climatic Resistance			
CR(S)	[Class] *4		1
Acid Resistance by Surface Method			
AR(S)	[Class]		1
Acid Resistance by Powder Method			
AR(P)	[Class] *5		1
Phosphate Resistance			
PR(S)	[Class] *6		1

Specific Gravity	2.20
------------------	------

Impurities

OH	< 1200 ppm	Al	< 100 ppb
Li	< 100 ppb	Ti	< 100 ppb
Na	< 100 ppb	Cr	< 100 ppb
K	< 100 ppb	Fe	< 100 ppb
Mg	< 100 ppb	Cu	< 100 ppb
Ca	< 100 ppb		

※Each property is shown as a typical value.

Note

*1	Excerpts from literature
*2	JOGIS09-1975
*3	JOGIS10-1994
*4	JOGIS07-2006
*5	JOGIS06-1999
*6	ISO 9689:1990
*7	$n^2-1 = \frac{P_1 \lambda^2}{\lambda^2-Q_1} + \frac{P_2 \lambda^2}{\lambda^2-Q_2} + \frac{P_3 \lambda^2}{\lambda^2-Q_3} + \frac{P_4 \lambda^2}{\lambda^2-Q_4}$
*8	$\Delta n_{abs} = \frac{n^2-1}{2n} \left[D_0 \Delta T + D_1 \Delta T^2 + D_2 \Delta T^3 + \frac{E_0 \Delta T + E_1 \Delta T^2}{\lambda^2 - \lambda_{tk}^2} \right]$

N.B. Export of the products* in this catalog is controlled under the Japanese Foreign Exchange and Foreign Trade Law. Appropriate export procedure shall be required in case of export from Japan.

*Products: Hardware and its technical information (including software)



NIKON CORPORATION

Industrial Solutions Business Unit

1-5-20, Nishioi, Shinagawa-ku, Tokyo,

140 8601, Japan

Tel +81-3-6743-5633 FAX +81-3-6410-7252

<https://www.nikon.com/products/components/>