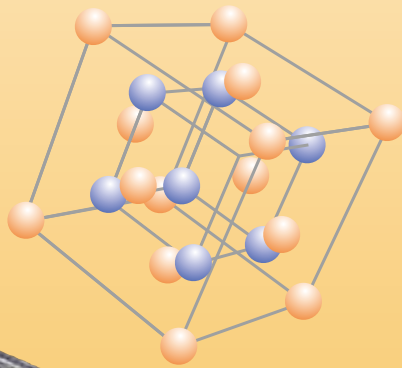




Nikon <sup>(th)</sup>  
100  
anniversary

Nikon Calcium Fluoride (CaF<sub>2</sub>)

# NICF Series



# Nikon NICF Series Calcium Fluoride

## NICF Series ADVANTAGES

### High laser durability

Nikon's strict process control and use of ultra-high-purity raw materials during the calcium fluoride growing process results in increased durability to long-term exposure to high-power excimer lasers.

### High quality crystals

Nikon is a leading supplier of large-sized, high-quality single crystal calcium fluoride. With our continuous process improvement cycle and optimized growing conditions, we can produce material with minimal lattice and structural defects, resulting in increased laser durability.

### High refractive index homogeneity

Nikon's proprietary annealing process yields unsurpassed refractive index homogeneity.

## Optical grades

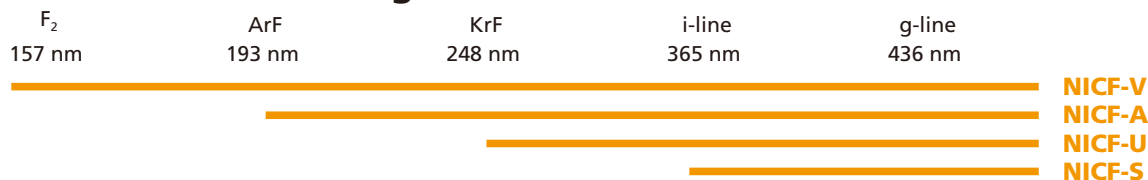
Grade	Internal transmittance [%] Sample thickness: 10 mm	Laser durability	Birefringence	Recommended wavelength
NICF-V	≥99.5 (at 157 nm)	A	2 - 20 nm/cm	VUV region, ArF excimer laser (193 nm)
NICF-A	≥99.8 (at 193 nm)	B	on request	ArF excimer laser (193 nm)
NICF-U	≥99.8 (at 248 nm)	C		KrF excimer laser (248 nm)
NICF-S	—	—	—	UV region, Visible region, IR region

※ Crystal orientation to be specified by the customer, <111>, random and custom orientations are available upon request.

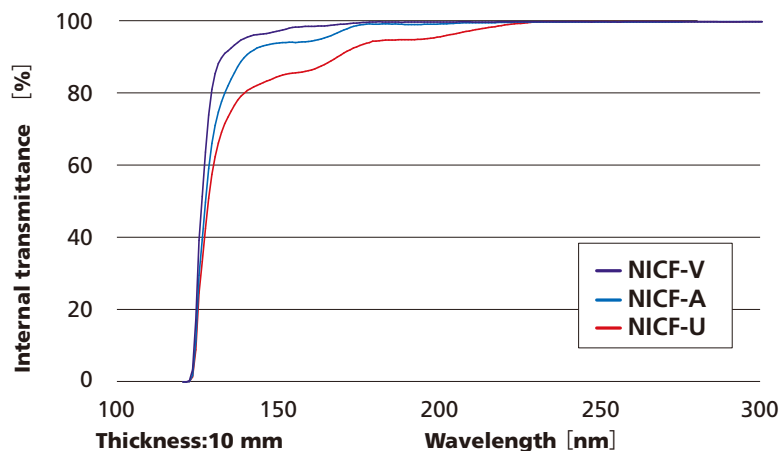
※ Values stated above are valid for material with a diameter of 30 - 260 mm and a thickness of 5 - 35 mm. Material outside this range will be regarded as custom.

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

## NICF Transmittance range



## Transmittance data — VUV-UV region —



## NICF Available range of homogeneity

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

## Properties of NICF-V, A, U (Nikon Calcium Fluoride)

$n_d$	1.43384	$v_d$	95.26
$n_e$	1.43492	$v_e$	94.72

### Optical Properties

Wavelength[ $\mu\text{m}$ ]	Refractive Indices	
-	2.32542	1.42211
-	1.97002	1.42401
-	1.52958	1.42613
-	1.0603	1.42850
t	1.01398	1.42879
s	0.85211	1.43002
r	0.70652	1.43166
C	0.65627	1.43245
C'	0.64385	1.43267
He-Ne	0.63280	1.43288
D	0.58929	1.43380
d	0.58756	1.43384
e	0.54608	1.43492
F	0.48613	1.43700
F'	0.47999	1.43726
g	0.43584	1.43946
h	0.40466	1.44148
i	0.36502	1.44488
-	0.33415	1.44848
-	0.31270	1.45170
-	0.29673	1.45463
-	0.2804	1.45823
KrF	0.2484	1.46786
-	0.19416	1.50059
ArF	0.1934	1.50133
-	0.18489	1.51052

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

Dispersion Coefficients *7	
P <sub>1</sub>	5.81797965E-01
P <sub>2</sub>	3.73232342E-01
P <sub>3</sub>	8.36771960E-02
P <sub>4</sub>	2.36293749E+00
Q <sub>1</sub>	2.47744200E-03
Q <sub>2</sub>	1.03202600E-02
Q <sub>3</sub>	1.03234730E-02
Q <sub>4</sub>	7.38225998E+02

Partial Dispersions	
F - C	0.004554
F' - C'	0.004592

Abnormal Dispersions	
$\Delta P_{C,t}$	-0.1940
$\Delta P_{C,s}$	-0.0918
$\Delta P_{F,e}$	0.0183
$\Delta P_{g,F}$	0.0553
$\Delta P_{i,g}$	0.2642

Relative Partial Dispersions	
$P_{s,t}$	0.2697
$P_{C,s}$	0.5332
$P_{d,c}$	0.3046
$P_{e,d}$	0.2388
$P_{g,F}$	0.5389
$P_{i,h}$	0.7465
$P'_{s,t}$	0.2675
$P'_{C',s}$	0.5769
$P'_{d,c'}$	0.2540
$P'_{e,d}$	0.2368
$P'_{g,F'}$	0.4783
$P'_{i,h}$	0.7404

Constants for Absolute $\Delta n/\Delta T$ *8			
D <sub>0</sub>	-3.16E-05	E <sub>0</sub>	4.32E-07
D <sub>1</sub>	-2.05E-08	E <sub>1</sub>	2.04E-10
D <sub>2</sub>	9.02E-13	$\lambda/\mu\text{m}$	1.15E-01

Effect of Temperature on Refractive Index			
°C	Absolute $\Delta n/\Delta T$ [ $10^{-6}/^{\circ}\text{C}$ ]		
	1060.0 nm	546.23 nm	365.12 nm
-40 ~ -20	-10.6	-10.3	-9.8
+20 ~ +40	-11.5	-11.2	-10.6
+60 ~ +80	-12.1	-11.8	-11.2

### Chemical/Electrical Properties

Crystal Structure	Cubic, Fluorite type	
Cleavage Plane	(111)	
Molecular Weight	78.08	
Climatic Resistance	1	
CR(S)	[Class] *4	
Acid Resistance by Surface Method	3	
AR(S)	[Class]	
Acid Resistance by Powder Method	1	
AR(P)	[Class] *5	
Phosphate Resistance	1	
PR(S)	[Class] *6	
Solubility in Water (20°C)	[g/l] *1	0.016
Dielectric Constants (27°C) *1	$\epsilon_r$	6.81

### Thermal Properties

Expansion Coefficient		
(-30 ~ +70°C) [ $10^{-6}/^{\circ}\text{C}$ ]	$\alpha$	18.4
(0 ~ +25°C) [ $10^{-6}/^{\circ}\text{C}$ ]		18.4
(+20 ~ +300°C) [ $10^{-6}/^{\circ}\text{C}$ ]		20.8
Thermal Conductivity(20°C) [W/m·K]	$\lambda$	9.70
Melting Point	[°C]	1360
Specific Heat Capacity	[J/g·K]	c 0.893
Thermal Diffusivity	[ $10^{-7}\text{m}^2/\text{sec}$ ]	$\kappa$ 35.60

### Mechanical Properties

Young's Modulus	[GPa]	E	146<100>
			101<110>
			91<111>
Poisson's Ratio		$\mu$	0.21
Knoop Hardness	[kgf/mm <sup>2</sup> ]*2	HK	164
Abrasion Hardness	*3	A	301
Shear Modulus	[GPa]	G	34.6
Compressive Modulus	[GPa]	-	83.8
Mohs Hardness	*1	-	4
Stress Optical Coefficient			1.77
(q <sub>11</sub> -q <sub>12</sub> ) @193nm	[ $10^{-12}/\text{Pa}$ ]	-	
Specific Gravity			3.18

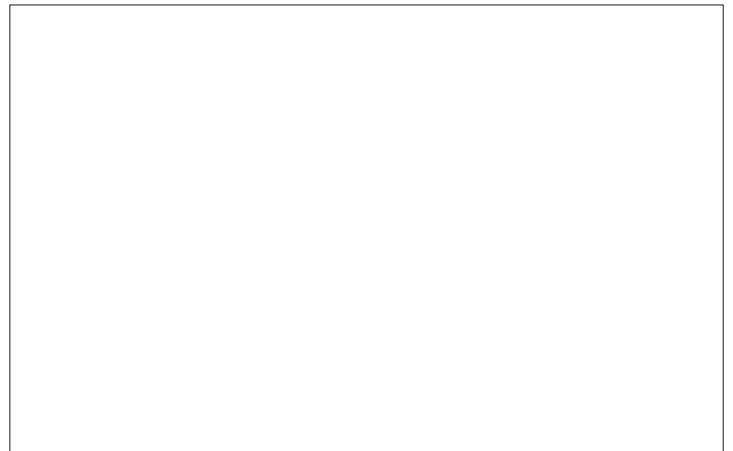
\*Each property is shown as a typical value.

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)



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