

INFRARED OPTICAL MATERIAL

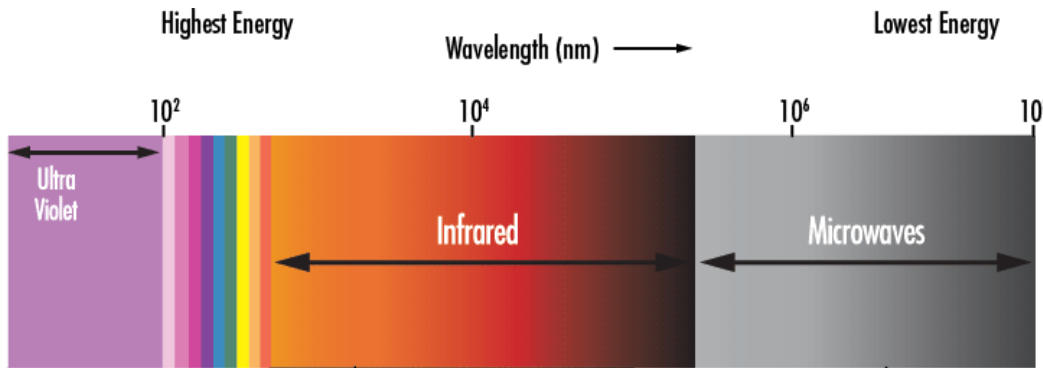


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STEPS TO CHOOSING INFRARED OPTICAL MATERIAL

- 1. Understand infrared technology and properties of optical materials**
- 2. Consider the top three material properties**
- 3. Compare optical materials**
- 4. Determine the optimum solution for the intended operation**

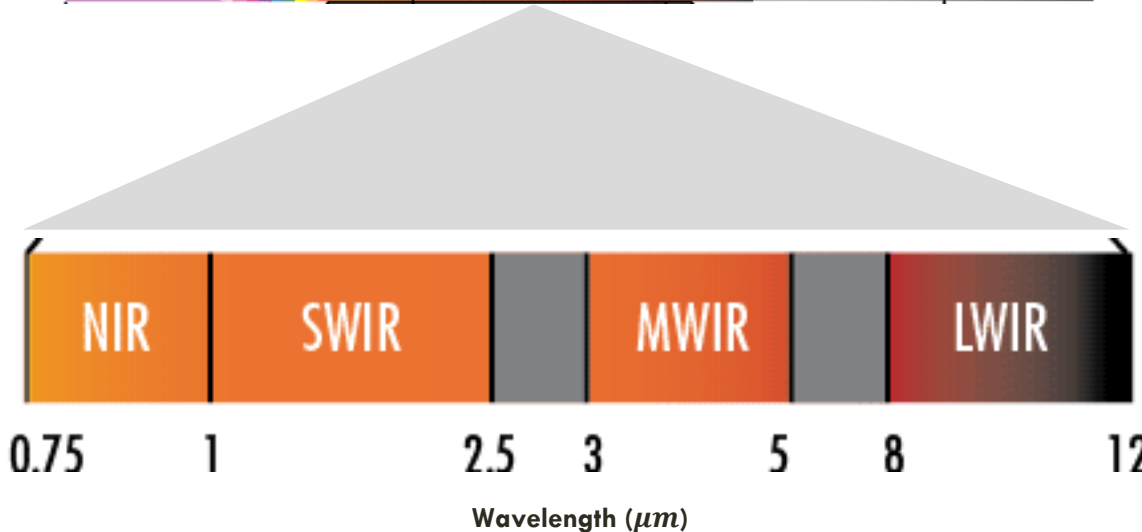
WHAT IS INFRARED (IR)?



Type of electromagnetic radiation

Includes 4 Bandwidths

- Near Infrared (NIR)
 - $0.75 - 1 \mu m$
- Short Wave Infrared (SWIR)
 - $1 - 2.5 \mu m$
- Mid Wave Infrared (MWIR)
 - $3 - 5 \mu m$
- Long Wave Infrared (LWIR)
 - $8 - 12 \mu m$



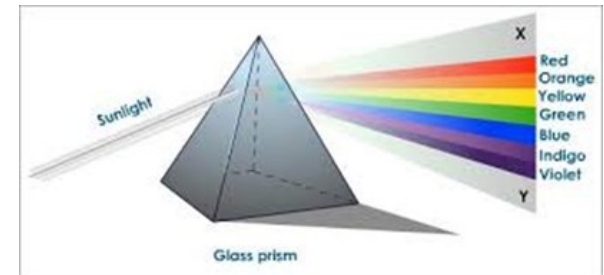
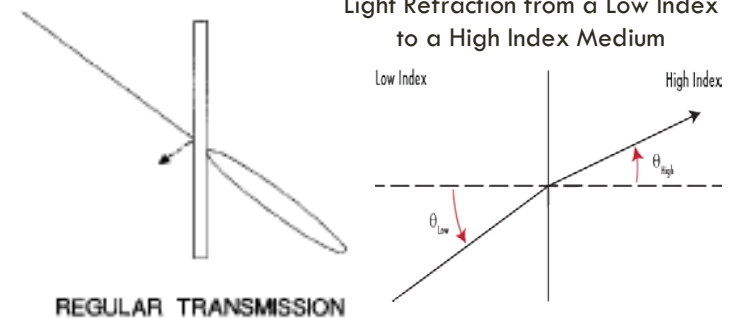
Infrared Technologies

- Thermal imaging
- IR spectroscopy
- Plano-optics

FIRST STEP TO CHOOSING IR OPTICAL MATERIALS

Understanding Optical Material Properties

- **Transmission**
 - Throughput Measurement
- **Index of Refraction**
 - Ratio of the speed of light in a vacuum to the speed of light within a given material
- **Dispersion**
 - Measure of how much the index of refraction of a material changes with respect to wavelength
- **Index Gradient**
 - Refraction of a medium varies as the temperature changes



HOW TO CHOOSE THE CORRECT MATERIAL

Three Simple Points to Consider

■ **Transmission**

- Consider the operation and the IR spectrum

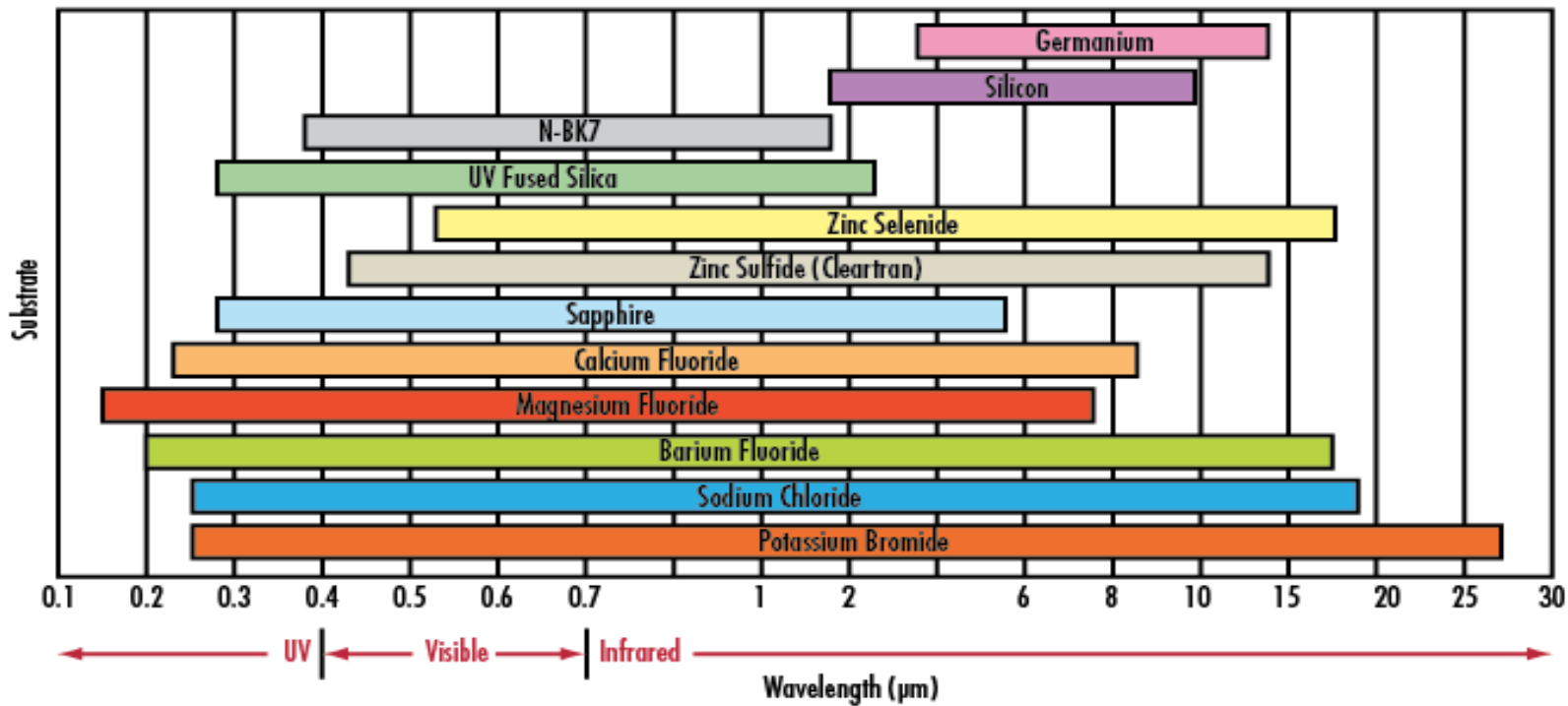
■ **Index of Refraction**

- IR materials vary in terms of index of refraction

■ **Thermal Properties**

- Evaluate the index gradient and coefficient of thermal expansion (CTE)

SUBSTRATE COMPARISON

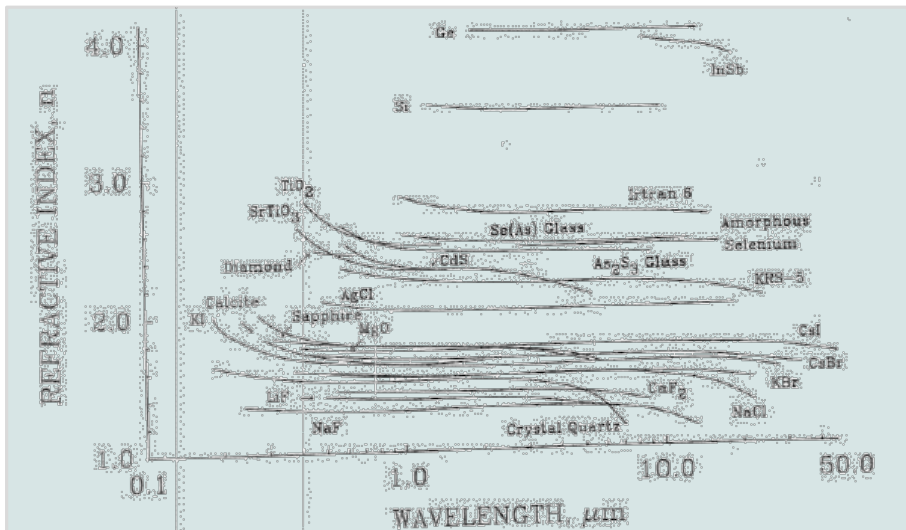


IR Materials are often limited to a small band

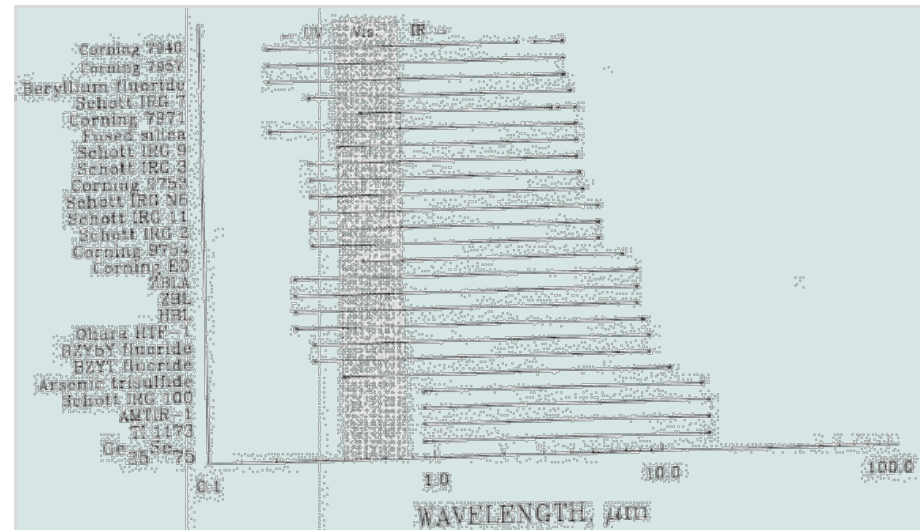
PHYSICAL PROPERTY COMPARISON

Material physical property tables available for comparison

- Refractive Index
- Transmission Regions
- Thermal Conductivity



Example of Refractive Index Table



Example of Transmission Regions Table

EXAMPLE: CALCIUM FLUORIDE (CaF₂)

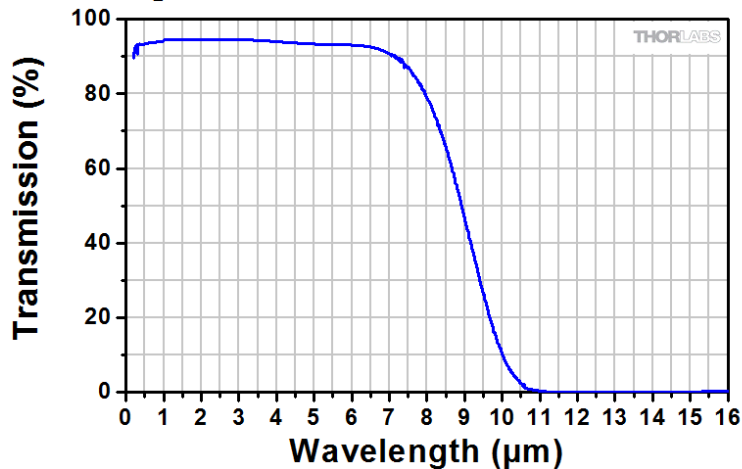
Three key material properties to consider

- Transmission
- Index of Refraction
- Thermal Properties

CaF₂ Refractive Index @ 24°C

Wavelength (um)	Computed Index	Wavelength (um)	Computed Index
0.228803	1.47635	1.39506	1.42675
0.24827	1.46793	1.52952	1.42612
0.2537	1.46602	1.7012	1.42531
0.2652	1.46233	1.81307	1.42478
0.28035	1.45828	1.97009	1.42401
0.296728	1.45467	2.1526	1.42306
0.334148	1.44852	2.32542	1.42212
0.34662	1.44694	2.4374	1.42147
0.365015	1.4449	3.3026	1.41561
Max Wavelength: 9.72		Refractive Index: 1.31	
Min Wavelength: 0.23		Refractive Index: 1.48	
0.4861327	1.43703	3.7067	1.41229
0.546074	1.43494	4.258	1.40713
0.589262	1.43381	5.01882	1.39873
0.643847	1.43268	5.3034	1.3952
0.6562793	1.43246	6.014	1.38539
0.6678149	1.43226	6.238	1.382
0.7065188	1.43167	6.63306	1.37565
0.767858	1.43088	6.8559	1.37186
0.85212	1.43002	7.268	1.36443
0.8944	1.42966	7.4644	1.3607
1.01398	1.42879	8.662	1.335
1.3622	1.42691	9.724	1.30756

CaF₂ Transmission (10 mm Thick Sample)



Temperature (K)	Thermal Conductivity (W/(m*K))
83	39
273	10
373	7.99

CaF₂ Thermal Conductivity

Temperature (K)	Thermal Expansion (x10 ⁻⁵ K ⁻¹)
75	4.8
300	18.9
900	36.6

CaF₂ Thermal Expansion

CALCIUM FLUORIDE SUMMARY

- Wide spectral range
 - 90% Transmission for $0.25\mu\text{m} - 7\mu\text{m}$
 - Operational at NIR-MWIR
 - Limited Operation at LWIR
- Low Absorption and High Damage Threshold
- High Coefficient of Thermal Expansion
 - Avoid High Operating Temperature Environments

Commonly Used

- Spectroscopy
- Cooled Thermal Imaging

SUMMARY

- IR is electromagnetic radiation
 - 4 Bandwidths (NIR, SWIR, MWIR, LWIR)
- Three material properties to consider
 - Transmission, Refractive Index, Thermal Properties
- Physical property tables available
- Consider operational conditions

BACK UP

REFERENCES

1. Edmunds Optics. *Edmunds Optics*. N.p., n.d. Web. 09 Dec. 2015.
2. Klocek, Paul. *Handbook of Infrared Optical Materials*. New York: M. Dekker, 1991. Print.
3. Bass, Michael. *Handbook of Optics*. N.p.: n.p., 2000. Print.