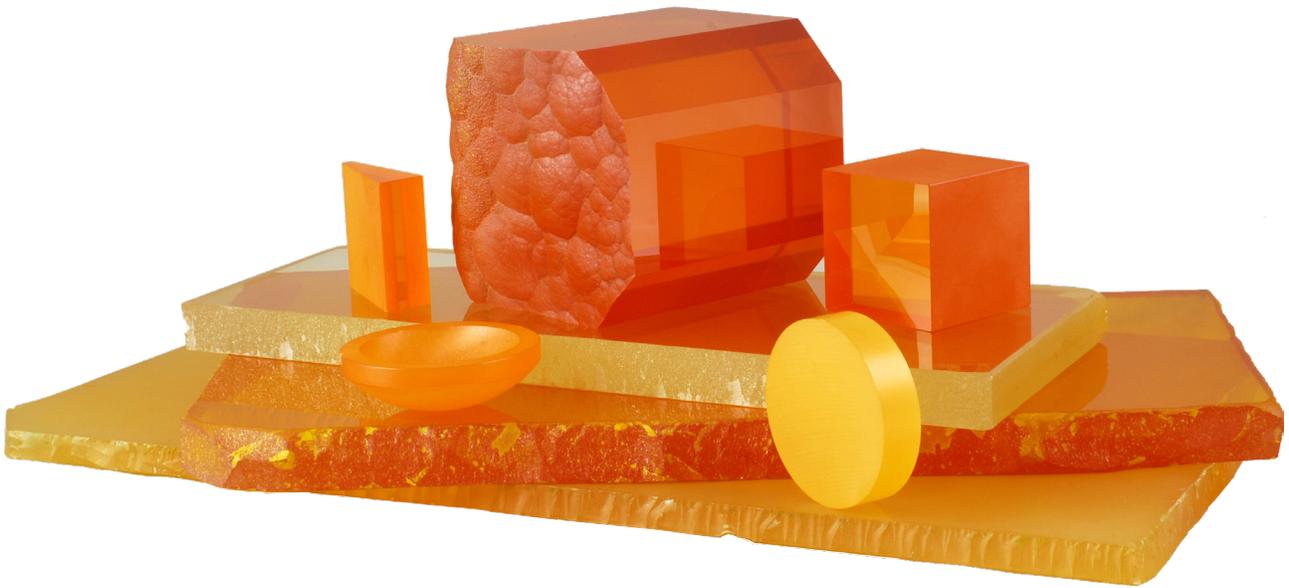


Optics

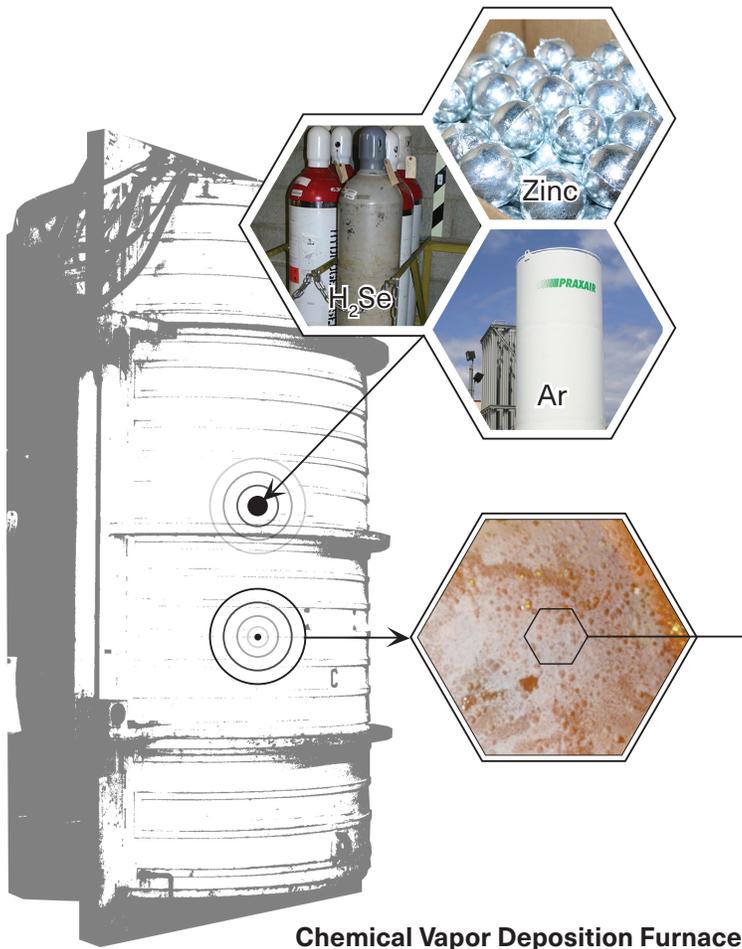
# OPTICAL MATERIALS

World's Leading Producer of Optical Materials



**COHERENT**

Coherent Incorporated was founded in 1971 to supply better materials to infrared optics producers. Initially producing cadmium telluride, Coherent began producing zinc selenide in the 1980s, and zinc sulfide during the 1990s. Today, Coherent's vertical integration, from materials growth through precision optics manufacturing, positions the company as the worldwide leader in CO<sub>2</sub> laser optics. Coherent is also the world's leading producer of ZnSe material. And our ZnS regular and ZnS MultiSpectral materials are used in a growing number of infrared systems both domestically and abroad. This brochure provides a comprehensive overview of our infrared materials capabilities. For additional information, contact a Coherent sales and support representative.



### Major Products

- Zinc Selenide (ZnSe)
- Zinc Sulfide (ZnS)
- Zinc Sulfide MultiSpectral (ZnS MS)

## Optical Fabrication Options

Coherent offers its infrared materials to customers who have their own optical manufacturing capability. Our ZnSe, ZnS, and ZnS MS are offered in a variety of shapes and configurations.



### Sheet Material

Materials can be ordered in sheet form by specifying the material's length x width x thickness. The material will be supplied to minimum +0.200" over the specified length and width. The thickness provided will be minimum +0.010" over specified thickness.



### Sufficient Material To Yield (SMTY)

Material ordered in this manner will be provided in irregularly shaped configurations that have been measured with templates to ensure they will yield a predetermined quantity of specific diameters. The thickness provided will be minimum +0.010" over specified thickness. It is important to take into account material removal amounts before specifying a SMTY thickness.



### Core-Drilled Blanks

Core-drilled blanks are initially machined with the closest oversized diameter core-drill tool that's at least 0.080" greater than the core-drilled blank diameter required by the customer. Core-drilled blanks have no bevels, edge chips will not exceed 0.030", and thickness is held to +/-0.010".



### Edged Blanks

Circular, square or rectangular parts are specified with standard dimensional tolerances of +0.000"/-0.005". Edged blanks have no bevels, edge chips will not exceed 0.015", and thickness is held to +/-0.010". Bevels can be provided when specified by customer.



### Generated Curved Lens Blanks

Blanks can be ordered with curves generated and edges beveled. Standard thickness tolerance is +/-0.010". Tolerances on radii depend upon the curve steepness in relation to diameter.

## Surface Finishes

Coherent offers the following surface finishes on ZnSe, ZnS, and ZnS MS blanks. Core-drilled blanks may contain any of the standard surface finishes unless otherwise specified.



### As Generated (AG)

Requires additional grinding prior to further processing for an optical finish.



### Fine Ground (FG)

Dull fine-ground finish free of scratches as viewed by the unaided eye.



### View Polished (VP)

Multi-stage mechanically polished to a transparent finish as viewed by the unaided eye; requires further processing for an optical finish. Used for inspection of internal quality cosmetics to guarantee the visual quality of the material. Edges are beveled and free of chips as viewed by the unaided eye.



### Zinc Selenide (ZnSe)

ZnSe is a preferred material for lenses, windows, output couplers, and beam expanders for its low absorptivity at infrared wavelengths and its visible transmission. For high-power applications, it's critical that the material bulk absorption and internal defect structure be carefully controlled, that minimum-damage polishing technology be employed, and the highest quality optical thin-film coatings be used. The material absorption is verified by CO<sub>2</sub> laser vacuum calorimetry. Our quality assurance department provides testing and specific optics certification on request. ZnSe optics are routinely polished from 5 to 300 mm in diameter. Sizes greater than 300 mm diameter and 25mm thick are manufactured to customer requirements. ZnSe is non-hygroscopic and chemically stable, unless treated with strong acids. It's safe to use in most industrial, field, and laboratory environments.



### Prism Grade Zinc Selenide (ZnSe)

Coherent has the capability to grow prism grade ZnSe exceeding 2.50" thick. Prism grade ZnSe exhibits minimal refractive index variations within the material on planes perpendicular to the growth direction as well as in other directions.

Index variations will test to less than 3 ppm at 0.6328 microns regardless of orientation. Prism grade ZnSe is commonly used in thermal imaging systems. Call our technical sales staff to discuss your specific requirements.

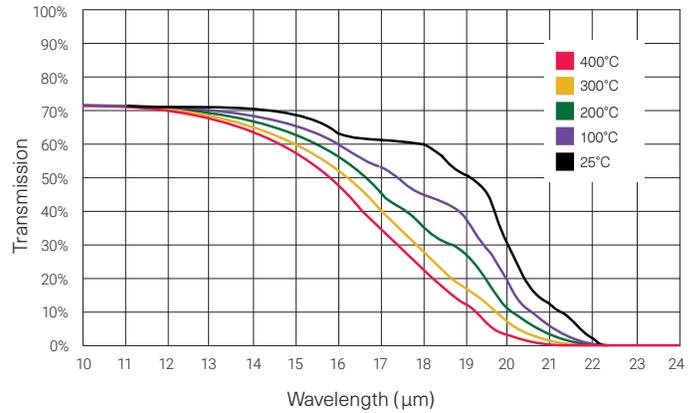
- Thickness exceeding 2.50"
- Consistent optical performance independent of orientation
- Refractive index variation less than 3 ppm @ 0.6328µm in all directions

ZnSe Material Properties		All values @ 20°C
<b>Physical Properties</b>		
Structure	Cubic zincblende	
Density	5.27 g/cm <sup>3</sup>	
Grain Size	< 100 µm	
Inclusions	None > 0.05 mm	
Electrical Density	> 10 <sup>12</sup> ohm-cm	
Dielectric Constant	Consult our technical staff	
<b>Optical Properties</b>		
Bulk Absorption Coefficient @ 10.6 µm	< 0.0005 cm <sup>-1</sup>	
Thermo-Optic Coefficient (dn/dT) @ 10.6 µm	6.1 x 10 <sup>-5</sup> /°C	
Refractive Index Inhomogeneity @ 0.6328 µm	< 3 x 10 <sup>-6</sup>	
<b>Thermal Properties</b>		
Thermal Conductivity @ 20° C	0.18 W/cm/°C	
Specific Heat	0.356 J/g/°C	
Linear Expansion Coefficient @ 20° C	7.57 x 10 <sup>-6</sup> /°C	
<b>Mechanical Properties</b>		
Young's Modulus	67.2 GPa (9.75 x 106 psi)	
Rupture Modulus	55.1 MPa (8,000 psi)	
Knoop Hardness	105-120 kg/mm <sup>2</sup>	
Density	5.27 g/cm <sup>3</sup>	
Poisson's Ratio	0.28	
Fracture Toughness	0.5 x 10 <sup>6</sup> N/m <sup>3/2</sup>	

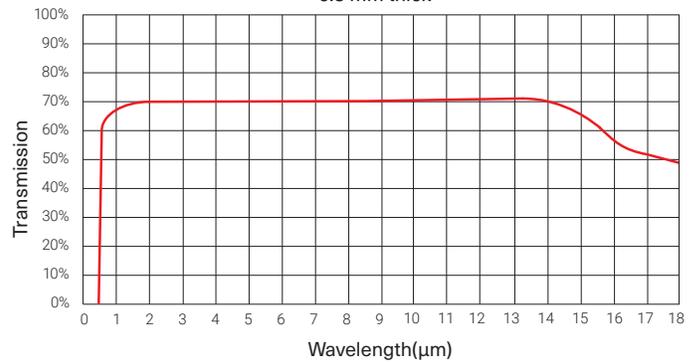
ZnSe Refractive Indices

Wavelength (μm)	Index	Wavelength (μm)	Index
0.54	2.6754	7.4	2.4201
0.58	2.6312	7.8	2.4183
0.62	2.5994	8.2	2.4163
0.66	2.5755	8.6	2.4143
0.70	2.5568	9.0	2.4122
0.74	2.5418	9.4	2.4100
0.78	2.5295	9.8	2.4077
0.82	2.5193	10.2	2.4053
0.86	2.5107	10.6	2.4028
0.90	2.5034	11.0	2.4001
0.94	2.4971	11.4	2.3974
0.98	2.4916	11.8	2.3945
1.0	2.4892	12.2	2.3915
1.4	2.4609	12.6	2.3883
1.8	2.4496	13.0	2.3850
2.2	2.4437	13.4	2.3816
2.6	2.4401	13.8	2.3781
3.0	2.4376	14.2	2.3744
3.4	2.4356	14.6	2.3705
3.8	2.4339	15.0	2.3665
4.2	2.4324	15.4	2.3623
4.6	2.4309	15.8	2.3579
5.0	2.4295	16.2	2.3534
5.4	2.4281	16.6	2.3487
5.8	2.4266	17.0	2.3448
6.2	2.4251	17.4	2.3387
6.6	2.4235	17.8	2.3333
7.0	2.4218	18.2	2.3278

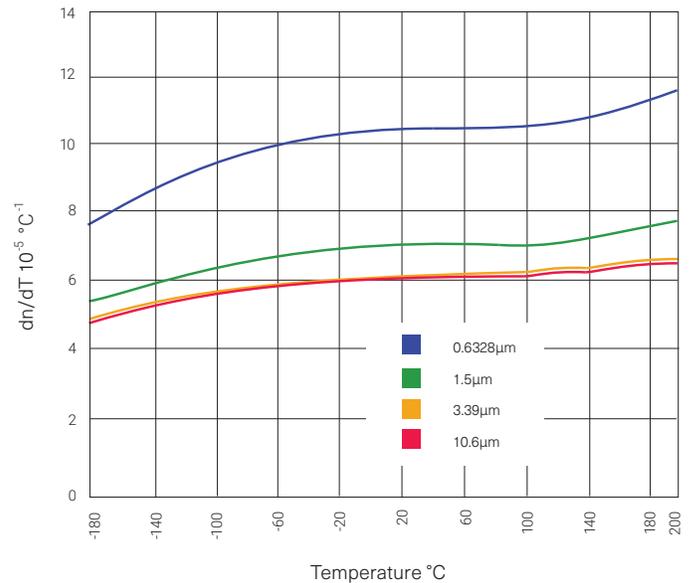
ZnSe Transmission vs. Temperature  
- 3 mm thick -



ZnSe Transmission  
- 6.3 mm thick -

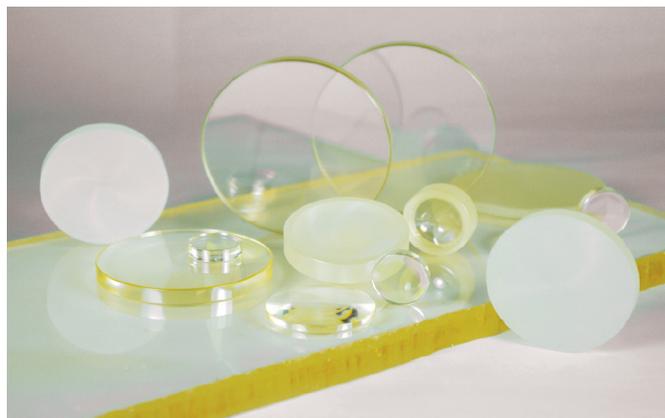


ZnSe Thermo-Optic Coefficient (dn/dT)



### Zinc Sulfide MultiSpectral (ZnS MS)

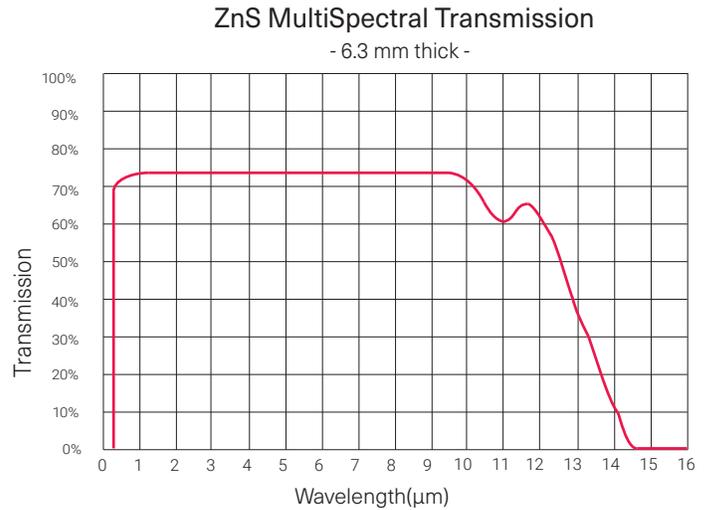
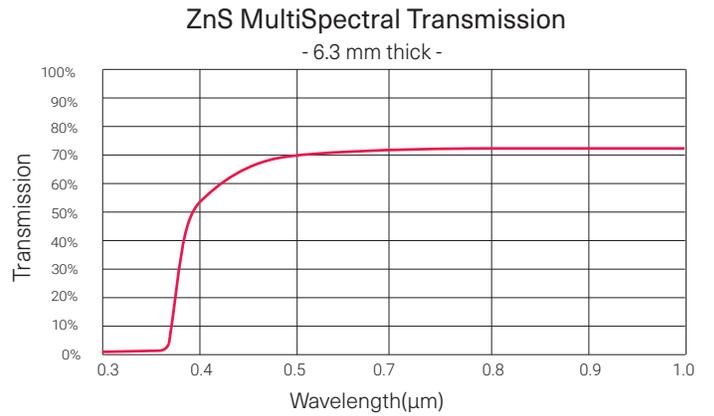
ZnS MultiSpectral is Coherent's zinc sulfide material treated by a hot isostatic press (HIP) process. Under intense heat and pressure, defects within the crystalline lattice are virtually eliminated, leaving a water-clear material with minimal scatter and high transmission characteristics from 0.4 to 12  $\mu\text{m}$ . This material is particularly well suited for high-performance common aperture systems that must perform across a broad wavelength spectrum. Coherent's extensive capabilities, equipment, and experience enable us to offer ZnS MS material to exacting specifications of dimensional shape and tolerances. ZnS MS material is also available in random sizes and shapes for use as evaporative source material.



ZnS MS Material Properties		All values @ 20°C
<b>Physical Properties</b>		
Structure	Cubic zincblende	
Density	4.09 g/cm <sup>3</sup>	
Grain Size	20 to 100 $\mu\text{m}$	
Inclusions	None > 0.2 mm	
Electrical Density	> 10 <sup>12</sup> ohm-cm	
Dielectric Constant	Consult our technical staff	
<b>Optical Properties</b>		
Bulk Absorption Coefficient @ 10.6 $\mu\text{m}$	_ < 0.20 cm <sup>-1</sup>	
Thermo-Optic Coefficient (dn/dT) @ 10.6 $\mu\text{m}$	5.4 x 10 <sup>-5</sup> /°C	
Refractive Index Inhomogeneity @ 0.6328 $\mu\text{m}$	< 20 x 10 <sup>-6</sup>	
Near Angle Forward Scatter @ 0.6328 $\mu\text{m}$	< 6%/cm	
<b>Thermal Properties</b>		
Thermal Conductivity @ 20° C	0.27W/cm/°C	
Specific Heat	0.527 J/g/°C	
Linear Expansion Coefficient @ 20° C	6.5 x 10 <sup>-6</sup> /°C	
<b>Mechanical Properties</b>		
Young's Modulus	85.5 GPa (12.4 x 10 <sup>6</sup> psi)	
Rupture Modulus	68.9 MPa (10,000 psi)	
Knoop Hardness	150-160 kg/mm <sup>2</sup>	
Density	4.09 g/cm <sup>3</sup>	
Poisson's Ratio	0.27	
Fracture Toughness	1.0 x 10 <sup>6</sup> N/m <sup>3/2</sup>	

ZnS MS Refractive Indices

Wavelength (μm)	Index	Wavelength (μm)	Index
0.4047	2.54515	1.1287	2.28485
0.4358	2.48918	1.5296	2.27191
0.4678	2.44915	2.0581	2.26442
0.4800	2.43691	3.000	2.25772
0.5086	2.41279	3.500	2.25498
0.5461	2.38838	4.000	2.25231
0.5876	2.36789	4.500	2.24955
0.6438	2.34731	5.000	2.24661
0.6678	2.34033	8.000	2.22334
0.7065	2.33073	9.000	2.21290
0.7800	2.31669	10.000	2.20084
0.7948	2.31438	11.250	2.18317
0.8521	2.30659	12.000	2.17101
0.8943	2.30183	13.000	2.15252
1.0140	2.29165		



## Zinc Sulfide (ZnS)

ZnS grown by chemical vapor deposition (CVD) at Coherent exhibits exceptional fracture strength and hardness leading to its frequent choice for military applications or other harsh environments. This material is often used in the 8 to 12  $\mu\text{m}$  region. Its high resistance to rain erosion, high-speed dust, and particulate abrasion, makes it especially suitable for exterior IR windows on aircraft frames. ZnS has a lower cost relative to ZnSe and ZnS MS, and has potential wherever a tough and strong IR transmitting material is required.



ZnS Material Properties		All values @ 20°C
<b>Physical Properties</b>		
Structure	Cubic zincblende	
Density	4.08 g/cm <sup>3</sup>	
Grain Size	2 to 8 $\mu\text{m}$	
Inclusions	None > 0.5 mm	
Electrical Density	> 10 <sup>12</sup> ohm-cm	
Dielectric Constant	Consult our technical staff	
<b>Optical Properties</b>		
Bulk Absorption Coefficient @ 10.6 $\mu\text{m}$	< 0.24 cm <sup>-1</sup>	
Thermo-Optic Coefficient (dn/dT) @ 10.6 $\mu\text{m}$	4.1 x 10 <sup>-5</sup> /°C	
Refractive Index Inhomogeneity @ 0.6328 $\mu\text{m}$	< 100 x 10 <sup>-6</sup>	
<b>Thermal Properties</b>		
Thermal Conductivity @ 20° C	0.167 W/cm/°C	
Specific Heat	0.469 J/g/°C	
Linear Expansion Coefficient @ 20° C	6.8 x 10 <sup>-6</sup> /°C	
<b>Mechanical Properties</b>		
Young's Modulus	74.5 GPa (10.8 x 10 <sup>6</sup> psi)	
Rupture Modulus	103.4 MPa (15,000 psi)	
Knoop Hardness	210-240 kg/mm <sup>2</sup>	
Density	4.08 g/cm <sup>3</sup>	
Poisson's Ratio	0.27	
Fracture Toughness	0.8 x 10 <sup>6</sup> N/m <sup>3/2</sup>	

ZnS Refractive Indices

Wave-length (μm)	Index	Wave-length (μm)	Index	Wave-length (μm)	Index
0.42	2.516	3.0	2.257	11.0	2.186
0.46	2.458	3.4	2.255	11.4	2.180
0.50	2.419	3.8	2.253	11.8	2.173
0.54	2.391	4.2	2.251	12.2	2.167
0.58	2.371	4.6	2.248	12.6	2.159
0.62	2.355	5.0	2.246	13.0	2.152
0.66	2.342	5.4	2.244	13.4	2.143
0.70	2.332	5.8	2.241	13.8	2.135
0.74	2.323	6.2	2.238	14.2	2.126
0.78	2.316	6.6	2.235	14.6	2.116
0.82	2.310	7.0	2.232	15.0	2.106
0.86	2.305	7.4	2.228	15.4	2.095
0.90	2.301	7.8	2.225	15.8	2.084
0.94	2.297	8.2	2.221	16.2	2.072
0.98	2.294	8.6	2.217	16.6	2.059
1.0	2.292	9.0	2.212	17.0	2.045
1.4	2.275	9.4	2.208	17.4	2.030
1.8	2.267	9.8	2.203	17.8	2.015
2.2	2.263	10.2	2.198	18.2	1.998
2.6	2.260	10.6	2.192		

