Germanium (Ge)

Germanium (Ge) is a relatively hard, high-density, **IR transmitting material** that blocks UV and VIS wavelengths but allows IR from 2µm.

Germanium covers the whole of the **8-14 micron** thermal band and is used in lens systems for **thermal imaging**. Germanium can be AR coated with Diamond producing an extremely tough front optic.

Germanium **transmits over 45% between 2-14µm up to 45ºC** but transmission degrades slowly at 100ºC then more rapidly above 200ºC. Exposure to higher temperatures can lead to catastrophic failure in the material so Germanium is unsuitable for use in these conditions. Additionally, its relatively high density should be considered where **weight** is an issue. Germanium has a hardness of HK780, slightly higher than GaAs with which it shares similar mechanical properties.

Typical applications for Germanium include **thermal imaging** where the material can be used as a front optic while its index of refraction makes Germanium useful for wide-angle lenses and microscopes. Additionally, Germanium components can be used for FLIR (Forward Looking Infrared) and FTIR (Fourier Transformed Infrared) spectroscopy systems, alongside other analytical instruments.

Germanium (Ge) is a high index material that is used to manufacture Attenuated Total Reflection (ATR) prisms for spectroscopy. Its refractive index is such that Germanium makes an effective natural 50% beamsplitter without the need for coatings. Germanium is also used extensively as a substrate for production of optical filters.

Properties of germanium glass:

Transmission Range :	1.8 to 23 µm
Refractive Index :	4.0026 at 11 µm
Reflection Loss :	53% at 11 µm (Two surfaces)
Absorption Coefficient :	<0.027 cm^{-1} @ 10.6 µm
Reststrahlen Peak :	n/a
dn/dT :	396 x 10^{-6} /°C
dn/dµ = 0 :	Almost constant
Density :	5.33 g/cc
Melting Point :	936 °C
Thermal Conductivity :	58.61 W m^{-1} K^{-1} at 293K
Thermal Expansion :	6.1 x 10^{-6}/°C at 298K
Hardness :	Knoop 780
Specific Heat Capacity :	310 J Kg^{-1} K^{-1}
Dielectric Constant :	16.6 at 9.37 GHz at 300K

Youngs Modulus (E) :	102.7 GPa
Shear Modulus (G) :	67 GPa
Bulk Modulus (K) :	77.2 GPa
Elastic Coefficients :	C_{11}=129; C_{12}=48.3; C_{44}=67.1
Apparent Elastic Limit :	89.6 MPa (13000 psi)
Poisson Ratio :	0.28
Solubility :	Insoluble in water
Molecular Weight :	72.59
Class/Structure :	Cubic Diamond, Fd3m

Refractive Index:
No = Ordinary Ray

µm	No	µm	No	µm	No
2.058	4.102	2.153	4.0919	2.313	4.0786
2.437	4.0708	2.577	4.0609	2.714	4.0562
2.998	4.0452	3.303	4.0369	4.258	4.0216
4.866	4.017	6.238	4.0094	8.660	4.0043
9.720	4.0034	11.04	4.0026	12.00	4.0023
13.02	4.0021				

Notes
Germanium is grown using the Czochralski technique by a small number of manufacturers in Belgium, USA, China and Russia. The refractive index of Germanium changes rapidly with temperature and the material becomes opaque at all wavelengths a little above 350K as the band gap floods with thermal electrons.