

Germanium (Ge)

MATERIALS DATA

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 350°K as the band gap floods with thermal electrons.

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

Transmission Range	1.8 to 23 μ m (1)
Refractive Index	4.0026 at 11 μ m (1)(2)
Reflection Loss	53% at 11 μ m (Two surfaces)
Absorption Coefficient	<0.027 cm ⁻¹ @ 10.6 μ m
Reststrahlen Peak	n/a
dn/dT	396 x 10 ⁻⁶ K ⁻¹ (2)(6)
dn/d μ = 0	Almost constant
Density	5.33 g/cc
Melting Point	936 °C (3)
Thermal Conductivity	58.61 W m ⁻¹ K ⁻¹ at 293K (6)
Thermal Expansion	6.1 x 10 ⁻⁶ K ⁻¹ at 298K (3)(4)(6)
Hardness	Knoop 780
Specific Heat Capacity	310 J Kg ⁻¹ K ⁻¹ (3)
Dielectric Constant	16.6 at 9.37 GHz at 300K
Youngs Modulus (E)	102.7 GPa (4) (5)
Shear Modulus (G)	67 GPa (4) (5)
Bulk Modulus (K)	77.2 GPa (4)
Elastic Coefficients	C ₁₁ =129; C ₁₂ =48.3; C ₄₄ =67.1 (5)
Apparent Elastic Limit	89.6 MPa (13000 psi)
Poisson Ratio	0.28 (4) (5)
Solubility	Insoluble in water
Molecular Weight	72.59
Class/Structure	FCC Cubic, Fm3m (#225) Diamond structure

(1) Handbook Optical Constants, ed Palik, V1, ISBN 0-12-544420-6

(2) Li, Refractive Index of Germanium etc, J.Phys Chem, V9, p561, 1980

(3) Pearson & Brattain, Proc. Inst. Radio Eng. V43, p1794, 1955

(4) Fine, J.App.Phys, V24, p338, 1953

(5) Wortman & Evans, V36, (1), P153 (1965)

(6) Hawkins, Sherwood, Djotni: Mid IR Filters for astronomical and remote sensing instrumentation.

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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				

