

Germanium is a material commonly used for basic elements of acousto-optic (AO) instruments operating in the mid-IR region.

Germanium-based instruments are most prevalent in the wavelength range between 9 and 11 μm . Second most common region of their application is between 5 and 6 μm . There is also a less frequently occurring but nevertheless important region between 2 and 3 μm , where the most common material, paratellurite (TeO_2) exhibits absorption bands.

We use monocrystalline germanium for optical elements including AO modulators and deflectors.

To determine the requirements for germanium components used in AO devices, refer to the following physical properties and key characteristics of AO-grade germanium.

Table 1. Key physical properties of germanium.

Density (298 K), g/cm ³	5.323
Tensile modulus, MPa	72.4
Mohs hardness	6
Fracture toughness, MPa ^{1/2}	1.004 (fracture plane 110)
Thermal shock resistance, °C	125
Poisson ratio, 125-375 K	0.278
Elastic constants, cm ² /N (298 K)	$S_{11} = 9.685 \times 10^{-8}$ $S_{12} = -2.70 \times 10^{-8}$ $S_{44} = 14.94 \times 10^{-8}$
Elastic coefficients, cm ² /N (298 K)	$C_{11} = 13.16 \times 10^6$ $C_{12} = 5.09 \times 10^6$ $C_{44} = 6.69 \times 10^6$
Young's modulus, N/cm ² (298 K)	$Y_{100} = 10.33 \times 10^6$ $Y_{110} = 13.80 \times 10^6$ $Y_{111} = 15.55 \times 10^6$
Shear modulus, N/cm ² (298 K)	$M_{100} = 6.69 \times 10^6$ $M_{110} = 4.1 \times 10^6$ $M_{111} = 4.9 \times 10^6$

Table 2. Acousto-optical properties of germanium.

N_{sw}	U_{sw}	$M_1, 10^{-7} \text{ cm}^2 \cdot \text{s/g}$	$M_2, 10^{-18} \text{ s}^2/\text{g}$	$M_3, 10^{-12} \text{ cm}^2 \cdot \text{s/g}$
[111]	[111]	10200	840	1850
[100]	[010]	1430	290	400

In table 2, N_{sw} is the direction of normal vector of the sonic wave, U_{sw} is the direction of the displacement vector of the sonic wave. The coefficients M_i describe the acousto-optical quality factor of the crystal. The parameters depend on basic limitations on the crystal dimensions and the field of application.

The table below summarizes the quality parameters of our optical components made of germanium:

Table 3. Germanium component data sheet.

Material	optical-grade monocrystal
Free aperture, %	>90
Diameter tolerance (width and length), mm	+0.0 / -0.1
Thickness tolerance, mm	+/- 0.1

Parallelism, arcmin	≤ 5
Surface quality, scr/dig:	
- for parts up to 3"	40/20
- for parts up to 8"	60/40
- for larger parts	80/50
Surface accuracy (overall – local error) at 633 nm, Newton's rings	1 – 1/2

Please pay attention that this article is only for your information. We do not supply raw germanium as well as semi-finished products. Our standard products are finished (polished, coated) parts.