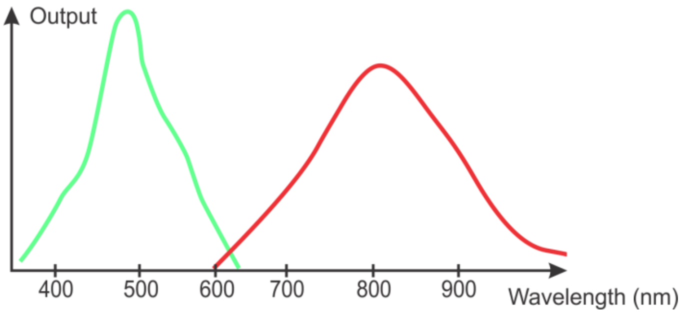
Ti:Sapphire Crystal

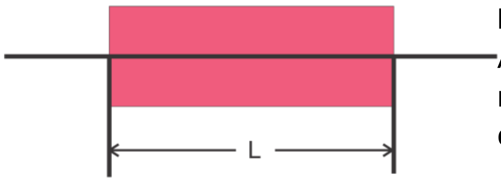
General description

Titanium doped Sapphire (Al_2O_3:Ti_3^+) is a popular crystal, used for making ultra short pulse solid-state or wavelength tunable lasers.

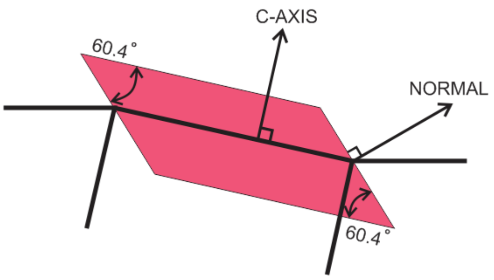


These crystals combine supreme thermal and optical properties with broadest lasing range among other materials. Its indefinite stability and short lifetime, in addition to lasing over entire band of 660 to 1050 nm makes Ti:sapphire lasers suitable for variety of applications spanning from material processing to time resolved and multi-photon spectroscopy.

Configurations



Right-angle cut is convenient for application of HR or AR coatings. This configuration is conveniently used in multi-pass amplifiers. L represents the length of the crystal.



Brewster-angle cut is used to eliminate reflection losses, increase polarization contrast, avoid formation of parasitic pulses in ultra-short pulse oscillators or even induce negative dispersion. Brewster cut faces are often left uncoated in order to increase damage threshold of the surface.

Using the Crystal

Ti:sapphire crystals have an absorption band in the green region. Radiation of around 500 nm is absorbed most effectively, however due to high availability and lower cost, green lasers (515 nm or 532 nm) are used to pump the medium.

The crystal can be effectively pumped by short pulse flashlamps in laser systems of high pulse energy or by a DPSS laser - in tunable continuous wave lasers and high repetition rate oscillators.

Because of high saturation power, in case of DPSS laser pumping, the pump beam should be of high transversal beam quality, high temporal stability and preferably strongly focused.
Recent studies have showed that diode pumping using a blue diode (445 nm) can also be used for making Ti:Sapphire oscillators. That is expected to raise the next generation of Ti:Sapphire lasers.

Features

- Large gain-bandwidth
- Very large emission bandwidth
- Excellent thermal conductivity
- Short upper-state lifetime (3.2 μs)
- High saturation power
- Relatively high laser cross-sections
- High damage threshold
- Strong Kerr effect

Applications

- Ultra-short pulse lasers
- High repetition rate oscillators
- Chirped-pulse laser amplifiers
- Multi-pass amplifiers
- Wavelength tunable CW lasers
- Pulsed X-ray generation

Absorption coefficient

Titanium Wt%	**α at 532 nm**
0.03%	0.60/cm ± 20%
0.05%	0.95/cm ± 20%
0.10%	1.50/cm ± 20%
0.15%	2.10/cm ± 20%
0.25%	4.10/cm ± 20%

Parameters

Refractive index @633	1.76
Fluorescence lifetime	3.2 μs
Temperature dependence of refractive index	13 x 10^{-6} K^{-1}
Thermal conductivity	33 W / (m K)
Emission cross section @790 nm	41 × 10^{-20} cm^2
Central absorption wavelength	495 nm
Chemical formula	Ti_3+:Al_2O_3
Crystal structure	hexagonal
Mass density	3.98 g/cm^3
Moh hardness	9
Young's modulus	335 GPa
Tensile strength	400 MPa
Melting point	2040 °C
Thermal expansion coefficient	≈ 5 × 10^{-6} K^{-1}
Thermal shock resistance parameter	790 W/m
Birefringence	negative uniaxial
Ti density for 0.1% at. doping	4.56 × 1019 cm^{-3}

What does figure of merit (FOM) for laser crystals mean?

Figure of merit is used to qualify the performance of laser crystal. Higher figure of merit refers to better crystal quality. FOM is defined as the ratio of absorption coefficients at the pump and lasing wavelengths (e.g. α800nm : α532nm). Characterization of each crystal's FOM or absorption parameters is available on request.

Production of Ti:Sapphire Crystals

Altechna offers Ti:Sapphire crystals precisely cut from a boule of large monocrystal. The crystal is grown using the Czochralski method, which includes steps of:

- melting of Al_2O_3 material with low concentration of Titanium;
- inserting a seed crystal to the melt;
- pulling the crystal out of the melt in highly controlled environment;
- cooling down the boule in a strict thermal regime;
- annealing the boule under strongly reducing atmosphere in order to achieve good balance between Ti^{3+} and Ti^{4+} ions*. That is how the Figure of Merit is achieved 150 or more.

**Ti^{3+} - Ti^{4+} ion pairs increase residual absorption in the infrared (800 nm) region, which decreases the FoM.*