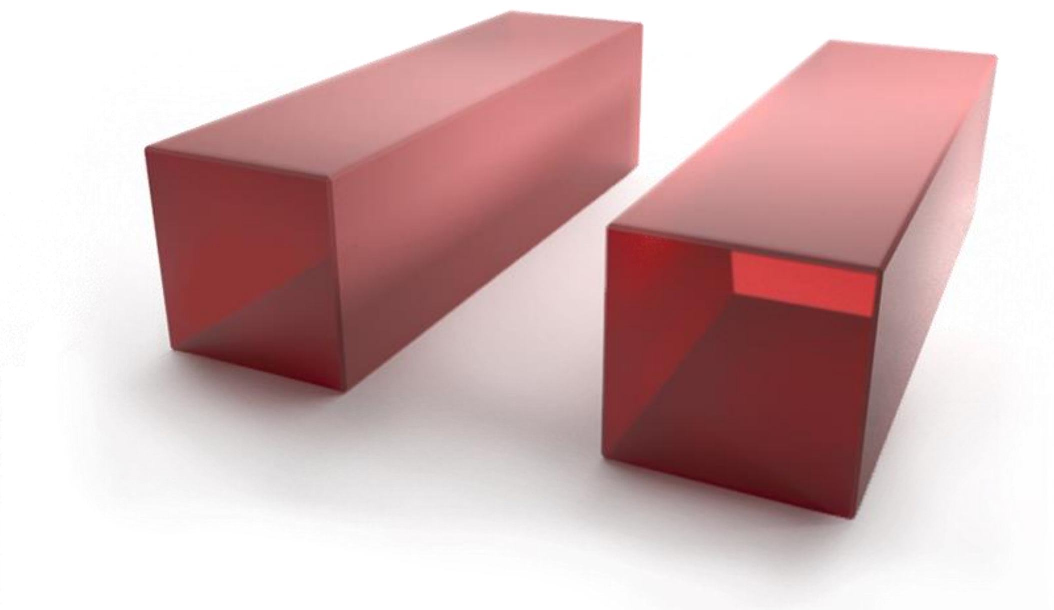
OPTOGAMA



Ti:SAPPHIRE LASER CRYSTAL

WHITE PAPER

Optogama, 2023

Titanium-doped sapphire ($Ti^{3+}:Al_2O_3$) has a very large gain bandwidth (670-1070 nm) in combination with excellent thermal conductivity and is used for ultrashort pulse generation and widely wavelength-tunable lasers.
The absorption and emission spectra of Ti:Sapphire crystal are shown in Fig.1., and the basic spectroscopic and thermomechanical properties are summarized in Table 1.

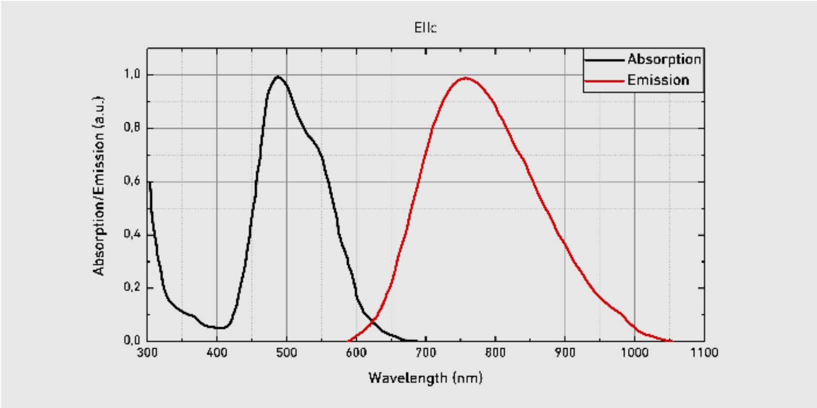
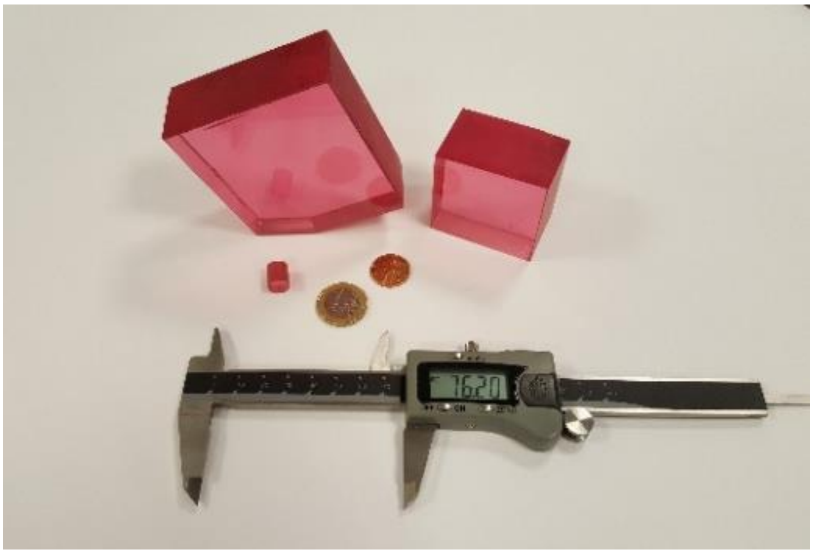


Fig. 1. Absorption and emission spectra of Ti:Sapphire



IMG 1. Examples of Ti:Sapphire crystal blanks

Table 1 SPECTROSCOPIC AND THERMOMECHANICAL PROPERTIES of Ti:Al2O3

Absorption peak wavelength	488 nm
Absorption cross-section at peak wavelength	3.8×10^{-19} cm^2
Laser wavelength	790 (670-1070) nm
Lifetime of energy level	3,2 µs
Emission cross-section @790 nm	4.1×10^{-19} cm^2
Refractive index @800 nm	1,76
Crystal structure	hexagonal
Density	3,98 g/cm^3
Mohs hardness	9
Thermal conductivity	33 Wm^{-1} K-1
dn/dT	13×10^{-6} K^{-1}
Thermal expansion coefficient	5×10^{-6} K^{-1}
Typical doping level	0,05-0,3 at.%

PUMPING SOURCES FOR Ti:SAPPHIRE LASERS

Pumping sources for Ti:Sapphire lasers include frequency-doubled diode-pumped Nd lasers, frequency-doubled fiber lasers and optically pumped semiconductor lasers (OPSL). The development of high-power InGaN-based semiconductor diode lasers has opened new possibilities for pumping Ti:Sapphire lasers. InGaN diode lasers can greatly reduce the complexity, size, and cost of Ti:Sapphire systems. Guidance on optimizing designs for InGaN diode-pumped Ti:Sapphire lasers can be found in reference [1], which considers some unexpected behavior, particularly with 450 nm pumping.

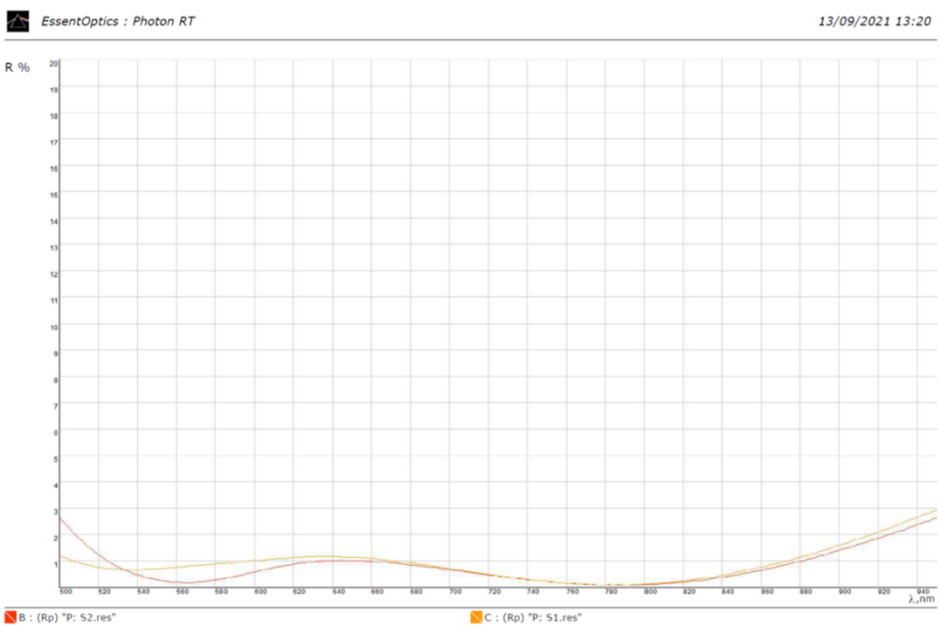
FEATURES OF Ti:SAPPHIRE LASER CRYSTALS FROM OPTOGAMA

- Titanium doping is from 0,05 to 0,3 at. %;
- Absorption coefficient is from 0,2 to 7,5 cm^{-1}@532 nm (E//c axis);
- FOM is from 150 (for high doped material) to >200 (for low doping material). The boule is annealed under strongly reducing atmosphere to achieve good balance between Ti^{3+} and Ti^{4+} ions;
- We have option to use corrective MRF polishing technique to improve transmitted wavefront distortion to $<\lambda/4$@632,8 nm;
- The standard surface quality is 10-5 S-D, controlling precise dimensional tolerances;
- Large size up to 110 x 110 x 40 mm.

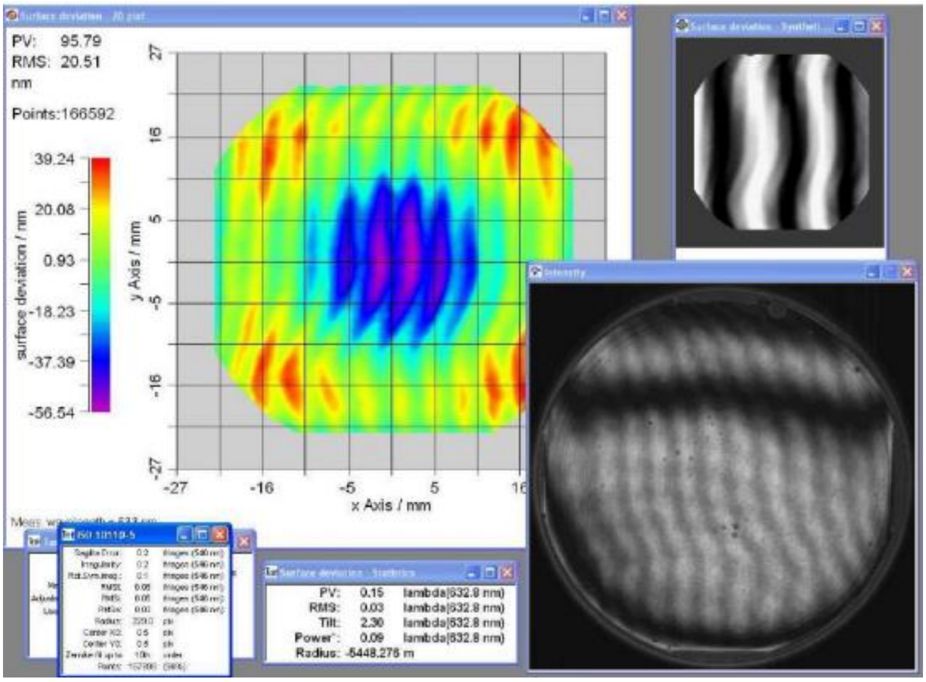
ANTIREFLECTION COATINGS

- Narrow band and broadband designs;
- Coating design and deposition technique are adopted for vacuum and cryogenic temperature environment;
- Laser induced damage threshold:

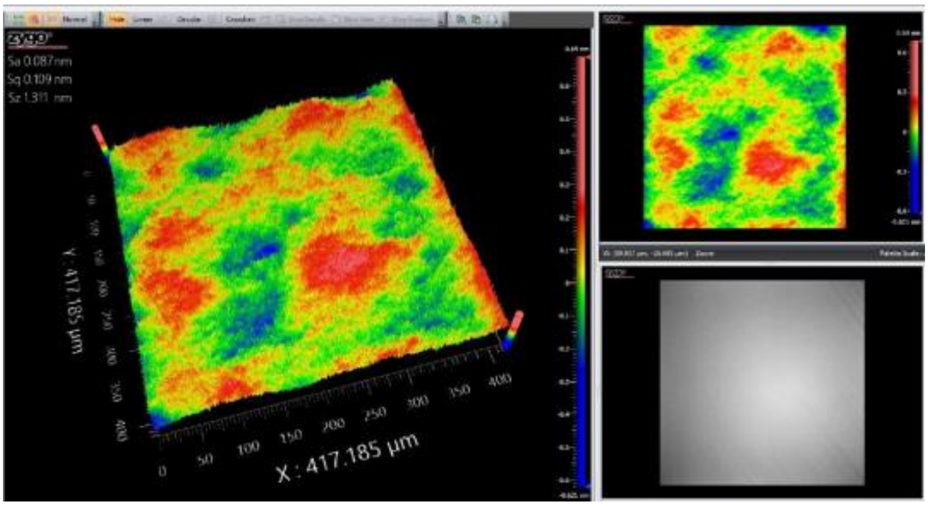
  >7 J/cm^2 @ 532 nm; 5 ns; 10 Hz;
  >2 J/cm^2 @ 800 nm; 300 ps; 10 Hz.



IMG 2. Broadband coating



IMG 3. Interferogram of large 50x50mm Ti:Sapphire crystal flatness



IMG 4. Surface roughness (<1Å PV) measurement result of our standard o6 x 20 mm crystal

References

1. PETER F. MOULTON, JEFFREY G. CEDERBERG, KEVIN T. STEVENS, GREG FOUNDOS, MICHAL KOSELJA, AND JANA PRECLIKOVA4 „Optimized InGaN-diode pumping of Ti:Sapphire crystals“, Optical Materials Express, 2019, Vol.9, No 5, PP.2131-2146.