



CRYSTAL CATALOG

(2017-2018)



Neodymium Doped Yttrium Orthovanadate (Nd:YVO₄)

Introduction

Nd:YVO₄ is the most efficient laser host crystal for diode pumping among the current commercial laser crystals, especially, for low to middle power density. This is mainly for its absorption and emission features surpassing Nd:YAG. Pumped by laser diodes, Nd:YVO₄ crystal has been incorporated with high NLO coefficient crystals (LBO, BBO, or KTP) to frequency-shift the output from the near infrared to green, blue, or even UV. This incorporation to construct all solid state lasers is an ideal laser tool that can cover the most widespread applications of lasers, including machining, material processing, spectroscopy, wafer inspection, light displays, medical diagnostics, laser printing, and data storage, etc. It has been shown that Nd:YVO₄ based diode pumped solid state lasers are rapidly occupying the markets traditionally dominated by water-cooled ion lasers and lamp-pumped lasers, especially when compact design and single-longitudinal-mode outputs are required.

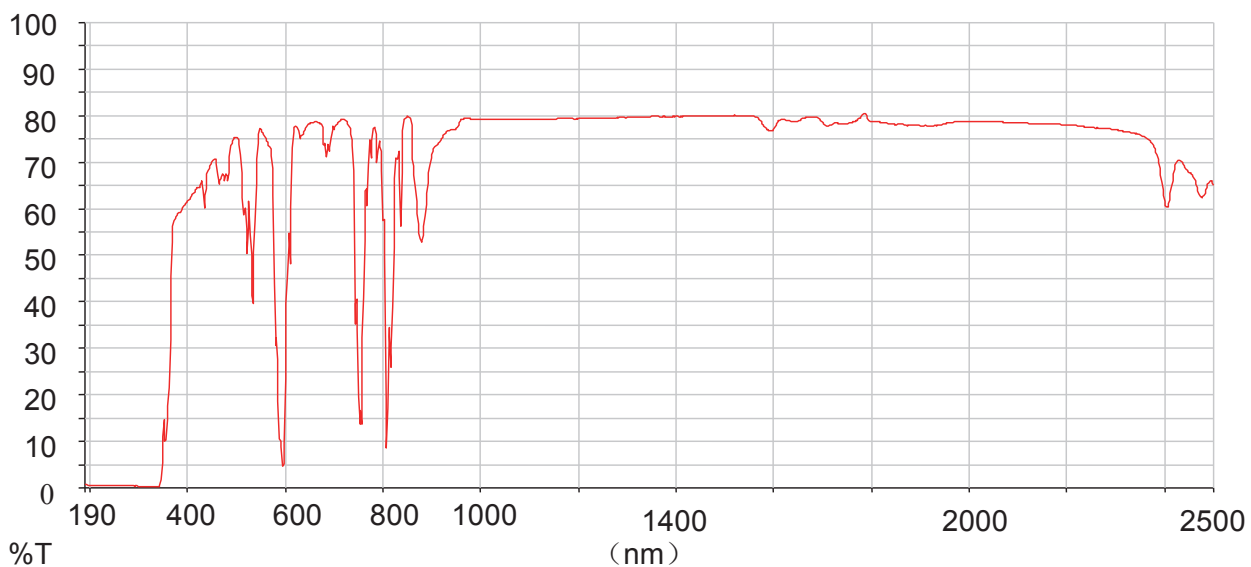
Nd:YVO₄ 's advantages over Nd:YAG

- As high as about five times larger absorption efficient over a wide pumping bandwidth around 808 nm (therefore, the dependency on pumping wavelength is much lower and a strong tendency to the single mode output)
- As large as three times larger stimulated emission cross-section at the lasing wavelength of 1064nm
- Lower lasing threshold and higher slope efficiency
- As a uniaxial crystal with a large birefringence, the emission is only a linearly polarized.

CASTECH Provides

- Various doping concentration from 0.1% to 3%.
- Doping concentration tolerance: $\pm 0.05\%$ (atm% < 1%), $\pm 0.1\%$ (atm% $\geq 1\%$)
- Various size bulk and finished high quality Nd:YVO₄ crystals up to $\phi 35 \times 50 \text{mm}^3$ and $\phi 20 \times 20 \text{mm}^3$, respectively;
- 10,000 pcs of Nd:YVO₄ devices per month in sizes $3 \times 3 \times 0.5$ to $4 \times 4 \times 8 \text{mm}$
- With quick delivery
- With competitive price.

Figure 1. Absorption Curve of 0.5% Nd:YVO₄(thickness 4mm)



Basic Properties

Crystal Structure: Cell Parameter:	Zircon Tetragonal, space group $D_{4h}-I4/amd$ $a=b=7.1193 \text{ \AA}$, $c=6.2892 \text{ \AA}$
Density:	4.22 g/cm^3
Atomic Density:	$1.26 \times 10^{20} \text{ atoms/cm}^3$ (Nd 1.0%)
Mohs Hardness:	4-5 (Glass-like)
Thermal Expansion Coefficient (300K):	$\alpha_a=4.43 \times 10^{-6}/\text{K}$ $\alpha_c=11.37 \times 10^{-6}/\text{K}$
Thermal Conductivity Coefficient (300K):	//C: 0.0523 W/cm/K \perp C: 0.0510 W/cm/K
Lasing Wavelength:	1064nm, 1342nm
Thermal Optical Coefficient (300K):	$dn_o/dT=8.5 \times 10^{-6}/\text{K}$ $dn_e/dT=2.9 \times 10^{-6}/\text{K}$
Stimulated Emission Cross-section:	$25 \times 10^{-19} \text{ cm}^2$ @1064nm
Fluorescent Lifetime:	90 μ s (1% Nd doped)
Absorption Coefficient:	31.4 cm^{-1} @810nm
Intrinsic Loss:	0.02 cm^{-1} @1064nm
Gain Bandwidth:	0.96nm @1064nm
Polarized Baser Emission:	π polarization; parallel to optical axis (c-axis)
Diode Pumped Optical To Optical Efficiency:	>60%
Sellmeier Equations(λ in μm)	$n_o^2=3.77834+0.069736/(\lambda^2-0.04724)-0.010813\lambda^2$ $n_e^2=4.59905+0.110534/(\lambda^2-0.04813)-0.012676\lambda^2$

Laser Properties of Nd:YVO₄

1. One most attractive character of Nd:YVO₄ is, compared with Nd:YAG, its 5 times larger absorption coefficient in a broader absorption bandwidth around the 808nm peak pump wavelength, which just matches the standard of high power laser diodes currently available. This means a smaller crystal that could be used for the laser, leading to a more compact laser system. For a given output power, this also means a lower power level at which the laser diode operates, thus extending the lifetime of the expensive laser diode. The broader absorption bandwidth of Nd:YVO₄ which may reaches 2.4 to 6.3 times that of Nd:YAG. Besides more efficient pumping, it also means a broader range of selection of diode specifications. This will be helpful to laser system makers for wider tolerance for lower cost choice.
2. Nd:YVO₄ crystal has larger stimulated emission cross-sections, both at 1064nm and 1342nm. When a-axis cut Nd:YVO₄ crystal lasing at 1064m, it is about 4 times higher than that of Nd:YAG, while at 1340nm the stimulated cross-section is 18 times larger, which leads to a CW operation completely outperforming Nd:YAG at 1320nm. These make Nd:YVO₄ laser be easy to maintain a strong single line emission at the two wavelengths.
3. Another important character of Nd:YVO₄ lasers is, because it is an uniaxial rather than a high symmetry of cubic as Nd:YAG, it only emits a linearly polarized laser, thus avoiding undesired birefringent effects on the frequency conversion. Although the lifetime of Nd:YVO₄ is about 2.7 times shorter than that of Nd:YAG, its slope efficiency can be still quite high for a proper design of laser cavity, because of its high pump quantum efficiency.



The major laser properties of Nd:YVO₄ vs Nd:YAG are listed in Table below, including stimulated emission cross-sections (σ), absorption coefficient (α), fluorescent lifetime (τ), absorption length (L_α), threshold power (P_{th}) and pump quantum efficiency (η_s).

Laser Properties of Nd:YVO₄ vs Nd:YAG

LASER CRYSTAL	DOPING (atm%)	σ ($\times 10^{-19} \text{cm}^2$)	α (cm^{-1})	τ (μs)	L_α (mm)	P_{th} (mW)	η_s (%)
Nd:YVO ₄ (a-cut)	1.0	25	31.2	90	0.32	30	52
	2.0	25	72.4	50	0.14	78	48.6
Nd:YVO ₄ (c-cut)	1.1	7	9.2	90		231	45.5
Nd:YAG	0.85	6	7.1	230	1.41	115	38.6

Typical Results

- Diode pumped Nd:YVO₄ laser output comparing with diode pumped Nd:YAG laser.

Crystals	Size (mm ³)	Pump Power	Output (at 1064nm)
Nd:YVO ₄	3x3x1	850mW	350mW
Nd:YVO ₄	3x3x5	15W	6W
Nd:YAG	3x3x2	850mW	34mW

- Diode pumped Nd:YVO₄+KTP green laser.
- 8W green laser was generated from a 15W LD pumped 0.5%Nd:YVO₄ with intracavity KTP.
- 200mW green outputs are generated from 1 W LD pumped 2%Nd:YVO₄ lasers by using CASTECH's 2x2x5mm KTP and 3x3x1mm Nd:YVO₄.

CASTECH provides the following coatings

- Both ends AR/AR-1064/808nm, R<0.2%@1064nm,R<2%@808nm
- S1:HR@1064&532 nm,HT808 nm, R>99.8%@1064&532nm,T>90%@808nm
S2:AR@1064&532 nm, R<0.2%@1064nm,R<0.5%@532nm
- S1:HR@1064,HT808, R>99.8%@1064nm,T>95%@808nm
S2:AR@1064, R<0.1%@1064nm.
- S1,S2 AR-coated, S3:gold/chrome plated.
- Both ends AR/AR-1064 nm; S3:AR-808 nm
- Other coatings are available upon request.



CASTECH's Warranty on Nd:YVO₄ Specifications

- Dimension tolerance: (W±0.1mm)x(H±0.1mm)x(L+0.5/-0.1mm) (L≥2.5mm)
(W±0.1mm)x(H±0.1mm)x(L+0.2/-0.1mm) (L<2.5mm)
- Clear aperture: central 90% of the diameter
- Flatness: less than $\lambda/8$ @ 633nm (L≥2.5mm); less than $\lambda/4$ @ 633nm (L<2.5mm)
- Transmitting wavefront distortion: less than $\lambda/4$ @ 633nm
- Chamfer: $\leq 0.2\text{mm}@45^\circ$
- Chip: $\leq 0.1\text{mm}$
- Scratch/Dig code: better than 10/ 5 to MIL-PRF-13830B
- Parallelism: better than 20 arc seconds
- Perpendicularity: ≤ 5 arc minutes
- Angle tolerance: $\leq 0.5^\circ$
- Damage threshold[GW/cm²]: >1 for 1064nm, TEM00, 10ns, 10Hz (AR-coated)
- Quality Warranty Period: one year under proper use.



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