

Neodymium: Gadolinium Vanadate - Nd:GdVO₄

Gadolinium vanadate doped with neodymium, Nd:GdVO₄, is a promising material for diode pumped lasers. Like neodymium doped yttrium vanadate, the gadolinium vanadate exhibits a larger absorption and emission cross section compared to Nd:YAG. In fact, Nd:GdVO₄ has a 7-times higher absorption cross section at 808nm and a 3-times larger emission cross section at 1.06μm than does Nd:YAG (Ref. 1). Nd:GdVO₄ has the additional advantage over Nd:YVO₄ of a much higher thermal conductivity.

Nd:GdVO₄ was first introduced as a laser material in 1992 by Zagumennyi, et al. (Ref. 2). Consequently, much less laser development and testing has occurred with gadolinium vanadate. The early results are, however, quite promising. Wang, et al. compared Nd:GdVO₄ and Nd:YVO₄ in a diode pumped arrangement (Ref. 3). In each case of cw laser performance at 1.06μm and 1.34μm and intracavity doubling with KTP and LBO, the gadolinium vanadate had a higher slope efficiency or optical conversion efficiency than did yttrium vanadate.

SYNOPTICS uses the Czochralski method to grow gadolinium vanadate. The crystal is tetragonal which means that there are two equivalent “a” directions and a “c” direction, all mutually orthogonal. A typical laser rod is oriented with the rod axis along an a-axis of the crystal. Maximum absorption of pump light occurs for polarization along the c-axis.

Demonstrated performance in diode pumped laser systems

Laser Operation	Output Wavelength (μm)	Frequency Doubler	Slope Efficiency (%)	Max Optical Conversion Efficiency (%)	Ref.
cw	1.06	none	44.6	n/a	3
cw	1.06	none	42.9	38.1	4
cw	1.34	none	40.2	n/a	3
cw	0.53	KTP	n/a	21.0	3
cw	0.67	LBO	n/a	2.8	3
Q-switched	1.06	none	31.6	n/a	1
Q-switched	0.53	KTP	n/a	25.0	4

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Information Regarding Neodymium Laser Host Crystals

	Nd:YVO ₄	Nd:GdVO ₄	Nd:YAG
Laser wavelengths (Ref. 5)	1064.3 nm 1342.0nm	1062.9 nm ~1340 nm	1064.2 nm 1338.2 nm
Emission bandwidth (linewidth at 1064 nm)	0.8 nm	No Data	0.45 nm
Effective laser cross section (emission cross section at 1064 nm)	15.6 x 10 ⁻¹⁹ cm ² (Ref.5)	7.6 x 10 ⁻¹⁹ cm ² (Ref.5)	6.5 x 10 ⁻¹⁹ cm ²
Polarization	Parallel to c-axis	Parallel to c-axis	Unpolarized
Radiative lifetime (microseconds) at 1% Nd doping	~100μs (Ref. 5)	~95μs (Ref. 5)	230μs
Pump wavelength (Ref. 5)	808.5 nm	808.4 nm	807.5 nm
Peak pump absorption at 1% doping (Ref. 5)	~41 cm ⁻¹	~57 cm ⁻¹	
Thermal conductivity, W/mK	5.1	11.7 (Ref. 7)	14
Doping concentration range	0.1 - 3.0%	0.1 - 3.0%	0.1 - 2.0%
Other possible dopants	Tm, Ho, Er	Tm, Ho, Er	Cr, Tm, Ho, Er, Yb

Material Properties: Comparing Nd:GdVO₄ and Nd:YVO₄

		Nd:GdVO ₄	Nd:YVO ₄
Crystal structure, Space group		Trtragonal. I4 ₁ /amd (Ref.4)	Trtragonal. I4 ₁ /amd
Lattice constants, nm	a	0.721	0.712
	c	0.635	0.629
Melting temperature, °C		1780 (Ref. 6)	1825
Thermal expansion @ 25°C, x 10 ⁻⁶ /°C	a	1.5	4.43
	c	7.3 (Ref.4)	11.4
Specific heat @25°C, cal/mol K		32.6 (Ref.4)	24.6 (Ref.4)
dn/dt, x 10 ⁻⁶ /°C		4.7 (Ref.4)	2.7 (Ref.4)

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