Neodymium: Gadolinium Vanadate - Nd:$GdVO_4$

Gadolinium vanadate doped with neodymium, Nd:$GdVO_4$, 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:$GdVO_4$ has a 7-times higher absorption cross section at 808nm and a 3-times larger emission cross section at 1µm than does Nd:YAG (Ref. 1). Nd:$GdVO_4$ has the additional advantage over Nd:YVO_4 of a much higher thermal conductivity.

Nd:$GdVO_4$ 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:$GdVO_4$ and Nd:YVO_4 in a diode pumped arrangement (Ref. 3). In case of cw laser performance at 1.06µm and 1.34µm with intracavity doubling with KTP and LBO, the gadolinium vanadate had a higher slope efficiency or optical conversion efficiency than did yttrium vanadate.

SYNOPTIC S 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

Neodymium Laser Host Crystal Information			
	$Nd:YVO_4$	**$Nd:GdVO_4$**	**Nd:YAG**
Laser Wavelengths (Ref. 5)	1064.2 nm 1342.0 nm	1062.9nm ~1340nm	1064.2 nm 1338.2 nm
Emission Bandwidth at 1064 nm	0.8 nm	No Data	0.45 nm
Effective emission Cross-Section at 1064 nm	15.6×10^{-19} cm^{-2} (Ref.5)	7.6×10^{19} cm^2 (Ref.5)	6.5×10^{-19} cm^{-2}
Polarization	Parallel to c-axis	Parallel to c-axis	Unpolarized
Radiative Lifetime (microseconds) at 1% Nd doping	~100 (Ref.5)	~95 (Ref. 5)	230
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	~10cm-1
Thermal Conductivity, W/mK	5.1	11.7 (Ref. 7)	14
Doping Conception Range	0.1 - 3.0%	0.1 - 3.0%	0.1 - 2.0%
Other Possible Dopants	Tm ,Ho, Er, Yb	Tm, Ho, Er, Yb	Cr, Tm, Ho, Er, Yb

Material Properties: $Nd:GdVO_4$ vs. $Nd:YVO_4$			
		$Nd:GdVO_4$	**$Nd:YVO_4$**
Crystal Structure		Tetragonal	Tetragonal
Space Group		$I4_1/amd$ (Ref.4)	$I4_1/amd$
Lattice Constants, nm	**a** **c**	0.721 0.635	0.712 0.629
Melting Temperature, °C		1780 (Ref. 6)	1825
Thermal Expansion @ 25°C, x 10^{-6} /°C	**a** **c**	1.5 7.3 (Ref.4)	4.43 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)

References:

1. C. Li, J. Song, D. Shen, N.S. Kim, J. Lu, K. Ueda, Appl. Phys. B, 70, 471 (2000)
2. A.I. Zagumennyi, V.G. Ostroumov, I.A. Shcherbakov, T. Jensen, J.P. Meyen, G. Huber, Sov. J. Quantum Electron., 22, 1071 (1992)
3. C.Q. Wang, Y.T. Chow, L. Reekie, W.A. Gambling, H.J. Zhang, L. Zhu, X.L. Meng, Appl. Phys. B, 70, 769 (2000)
4. H. Zhang, J. Liu, J. Wang, C. Wang, L. Zhu, Z. Shao, X. Meng, X. Hu, M. Jiang, Y.T. Chow, J. Opt. Soc. Am. B, 19 (1), 18 (2002)
5. L. DeShazer, Laser Focus World (Feb. 1994)
6. V.V. Kochurikhin, K. Shimamura, T. Fukuda, J. Crystal Growth, 151, 393 (1995)
7. L. Qin, X. Meng, J. Zhang, L. Zhu, H. Zhang, B. Xu, H. Jiang, J. Crystal Growth, 242, 183 (2002)

1-704-588-2340 • FAX 704-588-2516
1201 Continental Blvd., Charlotte, NC 28273
Email: STSynoptics.Sales@ngc.com
Website:www.as.northropgrumman.com/synoptics

NORTHROP GRUMMAN
SYNOPTICS