Laser Materials Tm:YAG

General Information

Tm:YAG is used as an efficient means to generate high power 2.01 micron laser emission from the $^3F_4$ - $^3H_6$ transition, for surgical cutting and coagulation applications due to the high water absorption at this wavelength [1]. Diode pumping is commonly employed into the 785nm $^3H_6$-$^3H_4$ absorption feature. Of interest in Tm^{3+} activated systems is the increased quantum efficiency obtained thru Tm-Tm ion cross relaxation; a non-radiative process where an excited Thulium in the $^3H_4$ state (energy level around 12900 cm −1) decays to the $^3F_4$ state (energy level around 6000 cm −1) and a nearest neighbor ground-state Thulium ion is promoted to the $^3F_4$ level, along with phonon byproduct to satisfy energy conservation [2]. Thus, in appropriate concentrations, a single Thulium ion excited to the $^3H_4$ level generates two Thulium ions in the $^3F_4$ upper laser level.

When cooled to cryogenic temperatures, the $^3H_6$-$^3H_4$ line of low doped Tm:YAG exhibits very narrow homogeneously broadened absorption features (on the order of ~kHz), embedded within a broad (~30GHz) inhomogeneously broadened line. This combination of properties has been shown to have significant importance to next generation quantum computing protocols [3], real-time broad-band spectral analysis for electronic awareness applications[4], and high time-bandwidth product signal processing applications [5].

Contact us with your specific requirements or for availability and pricing.

Dopant Ion

Tm3+ concentration range	0.005 - 100 atomic %
Dopant Ion Density @ 1 atomic %	
Y3+ Site	1.38×10^{20} cm^{-3}
Al3+Site (IV)	1.38×10^{20} cm^{-3}
Al3+Site (VI)	0.92×10^{20} cm^{-3}

Common Operating Specs

Emission Wavelength	2.01 μm
Laser Transition	$^3H_4 \rightarrow \, ^3H_6$
Pump Wavelength	785 nm

Physical Properties

Coefficient of Thermal Expansion	6.14×10^{-6} K^{-1}
Thermal Diffusivity	0.041 cm^2 s^{-2}
Thermal Conductivity	11.2 W m^{-1} K^{-1}
Specific Heat (Cp)	0.59 J g^{-1} K^{-1}
Thermal Shock Resistant	800 W m^{-1}
Refractive Index @ 632.8 nm	1.83
dn/dT (Thermal Coefficient of Refractive Index) @ 1064nm	7.8 10^{-6} K^{-1}
Molecular Weight	593.7 g mol^{-1}
Melting Point	1965°C
Density	4.56 g cm^{-3}
MOHS Hardness	8.25
Young's Modulus	335 Gpa
Tensile Strength	2 Gpa
Crystal Structure	Cubic
Standard Orientation	<111>
Y3+ Site Symmetry	D_2
Lattice Constant	a=12.013 Å

Absorption Coefficient Chart

3.6% Tm:YAG

References

1) *T.Back et al., "Thulium :Yag 2micron cw laser prostatectomy :where do we stand" World J Urol. 28, 163-168 (2010).

2) A. A. Kaminskii, "Crystaline Lasers: Physical Processes and Operating Schemes", CRC Press, (1996) Chapter 8, ISBN:0-8493-3720-8

3) M. Tian, et al., "Demonstration of geometric operations on the Bloch vectors in an ensemble of rare-earth metal atoms "PHYSICAL REVIEW A 79, 022312 (2009)
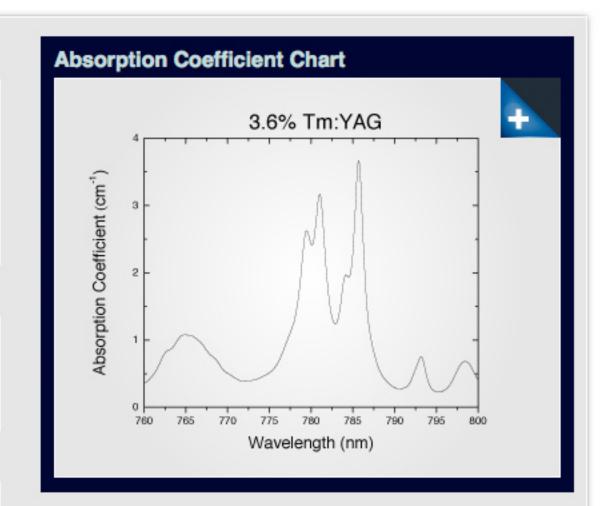
A. Louchet, et al., "Optical Excitation of Nuclear Spin Coherence in Tm3+:YAG" Phys. Rev. B 877 p. 195110 (2008)

O. Guillot-Noël, et al., "Quantum storage in rare-earth doped crystals for secure networks" J. Lumin. 122-123 p. 526-528 (2007)

A. Louchet, et al., "Branching ratio measurement of a "Lambda" system in Tm3+:YAG under magnetic field" Phys. Rev. B 75 p. 035131 (2007)

4) Z. W. Barber, et al., "Angle of arrival estimation using spectral interferometry" J. Lumin. 130 (2010) 1614-1618

R. K. Mohan, et al., "Ultra-wideband spectral analysis using S2 technology," J. Lumin. 127, 116-128 (2007).

G. Gorju, et al., "10 GHz RF spectrum analyzer with MHz resolution based on spectral-spatial holography in Tm3+:YAG: experimental and theoretical study" J. Opt. Soc. Am. B 24 p. 457-470 (2007)

M. Colice, et al., "Broadband radio-frequency spectrum analysis in spectral-hole-burning media" APPLIED OPTICS, Vol. 45, No. 25, page 6393 (2006)

5)R. Reibel, et al., "Demonstrations of analog-to-digital conversion using a frequency domain stretched processor," Optics Express 17, 11281-11286 (2009).

Z. Cole, et al., "Unambiguous Range-Doppler LADAR processing using 2 giga-sample-per-second noise waveforms," J. Lumin. 127, 146-151 (2007).

C. J. Renner, et al., "Broadband photonic arbitrary waveform generation based on spatial-spectral holographic materials," JOSA B, Vol. 24, 2979-2987 (2007).

T. L. Harris, et al., "Multigigahertz range-Doppler correlative signal processing in optical memory crystals," Applied Optics, 45(2), 343-352 (2006).