

Chromium, Thulium, Holmium: Yttrium Aluminum Garnet - CTH:YAG

CTH:YAG is a new crystal material which lases at 2080 nm. It has applications in medical, military and meteorological fields.

The key to efficient operation lies in the energy transfer processes between co-dopants of Cr, Tm and Ho. Cr³⁺ acts to effectively absorb flashlamp energy, which is then transferred to the Tm³⁺ with an efficiency of > 90%. A Tm:Tm cross relaxation then occurs and converts this energy into the IR with a quantum efficiency approaching 2, after which the Tm:Tm energy migration facilitates an efficient Tm:Ho energy transfer.

Advantages Of Cr,Tm,Ho:YAG Include:

High-efficiency 2 μm source

- Cr-Tm transfer quantum efficiency approaching 2
- Operates well at room temperature⁽¹⁾
- May be flashlamp or diode pumped

Laser diode sources can pump the strong 780 nm Tm³⁺ ion absorption line

- Chromium doping not necessary for diode-pumped applications
- Pump linewidth of 4 nm; 4 times wider than the corresponding Nd:YAG diode-pump linewidth

Operates in a relatively eye-safe wavelength range

- Should lead to military and scientific applications in coherent radar and range-finding

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Standard Rod Specifications

Material Parameters

Host: Yttrium Aluminum Garnet ($Y_3Al_5O_{12}$)
Standard Melt Concentrations:
Chromium (Cr^{3+}): 0.85 at %
Thulium (Tm^{3+}): 5.90 at %
Holmium (Ho^{3+}): 0.36 at %

(Other Compositions Available)

Orientation: [111] within 5 degrees
Wavefront Distortion: less than 1/2 wave per
inch of length
(measured at 1064 nm)

Dimensional Tolerances

Diameter: +0.000" / -0.002"
Length: +0.040" / -0.000"
Barrel Finish: 55 ± 5 μ inch (RMS)
Chamfer: $0.005" \pm 0.003"$ at $45^\circ \pm 5^\circ$

End Configuration

Flatness: less than $\lambda / 10$ wave
(measured at 632.8 nm)
Parallelism: less than 30 seconds of arc
Perpendicularity: less than 5 minutes of arc
Scratch-Dig: 10 - 5 per MIL-O-13830A

Anti-Reflection Coatings

Reflectivity: less than 0.25% at 2080 nm
Adhesion and Durability: meets MIL-C-48497A standards
Pulsed Damage Threshold: greater than $10 Jcm^{-2}$

Properties Of Cr,Tm,Ho:YAG

Lasing Properties

Lasing Transition: $^5I_7 - ^5I_8$
Lasing Wavelength: 2080 nm
Fluorescence Lifetime: 8.5 ms
Emission Cross Section⁽²⁾: $7 \times 10^{-21} cm^2$

Spectral Properties

Index of Refraction: 1.80 (at 2080 nm)
Diode Pump Band: 781 nm
Absorption Linewidth: 4 nm
Major Pump Bands: 400 - 800 nm

References

1. G. Huber, E. W. Duczynski and K. Petermann, "Laser Pumping of Ho-, Tm-, Er-Doped Garnet Lasers at Room Temperature," *J. Quantum Electronics*, **24**, (1988), 920.
2. T.Y. Fan, G. Huber, R.L. Byer and P. Mitzscherlich, "Spectroscopy and Diode Laser-Pumped Operation of Tm, Ho:YAG," *J. Quantum Electronics*, **24** (1988), 924.



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