Tm:YAP & Tm:YAG

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Introduction

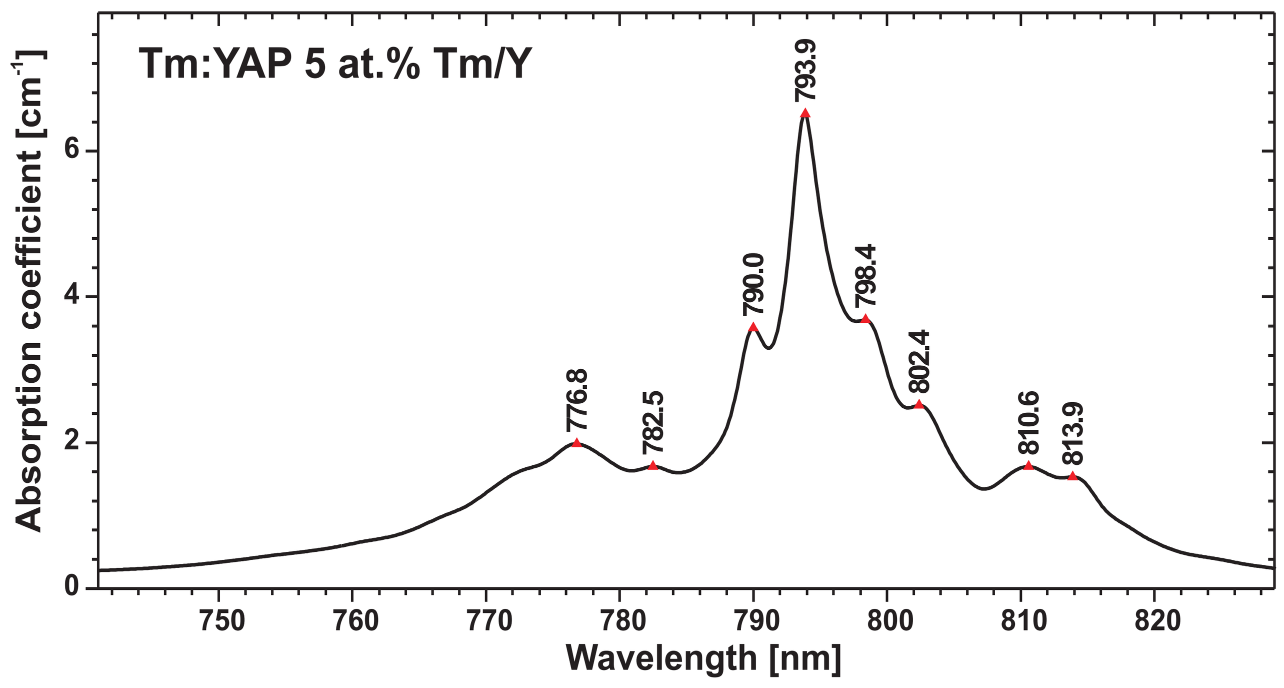
Tm doped crystals embrace several attractive features that nominate them as the material of choice for solid-state laser sources with emission wavelength tunable around 2 μm. It was demonstrated that Tm:YAG laser can be tuned from 1.91 up to 2.15 μm. Similarly, Tm:YAP laser has tuning range from 1.85 to 2.03 μm. The quasi-three level system of Tm:doped crystals requires appropriate pumping geometry and good heat extraction from the active media. On the other hand, Tm doped materials benefit from a long fluorescence lifetime, which is attractive for high-energy Q-switched operation. Also, the efficient cross-relaxation with neighbouring Tm^{3+} ions produces two excitation photons in upper laser level for one absorbed pump photon. This makes the laser very efficient with quantum efficiency approaching two and reduces thermal loading.

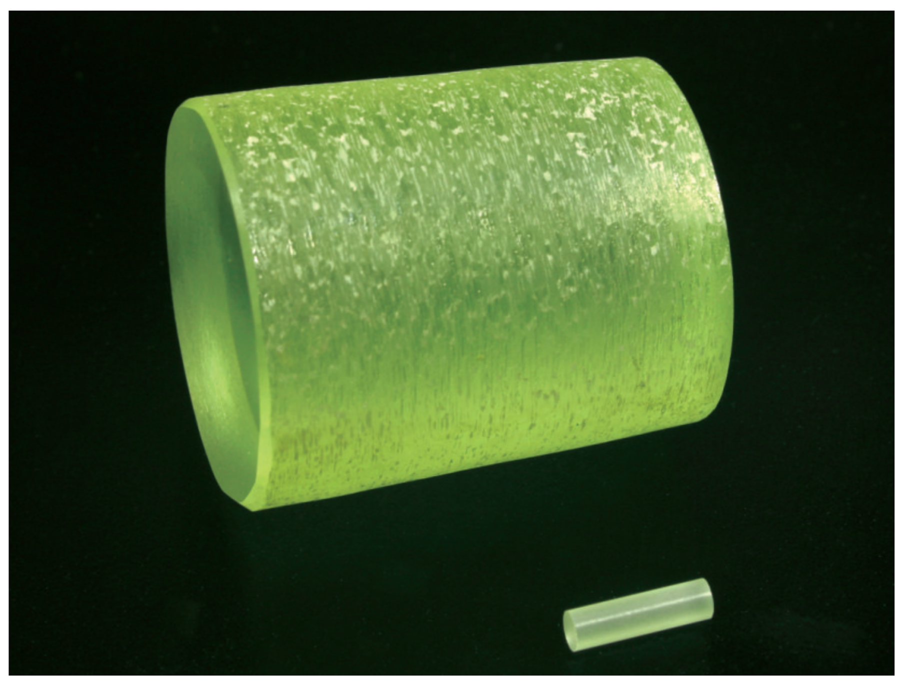
Tm:YAG and Tm:YAP found their application in medical lasers, radars and atmospheric sensing.

Tm:YAP

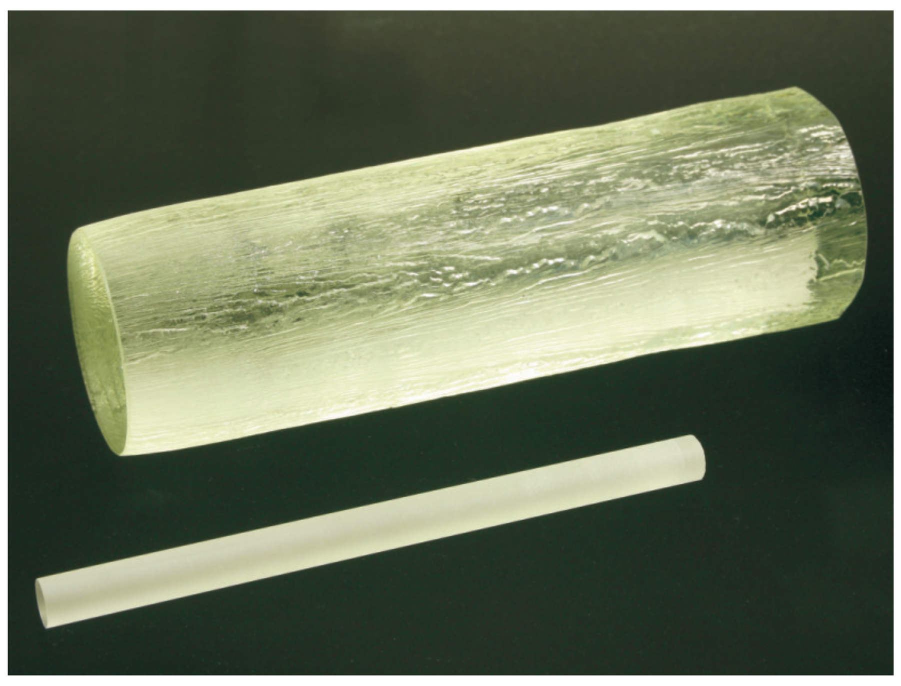
Properties of Tm:YAP depends on crystal orientation. Crystals cut along the „a“ or „b“ axis (Pbnm space group) are mostly used.

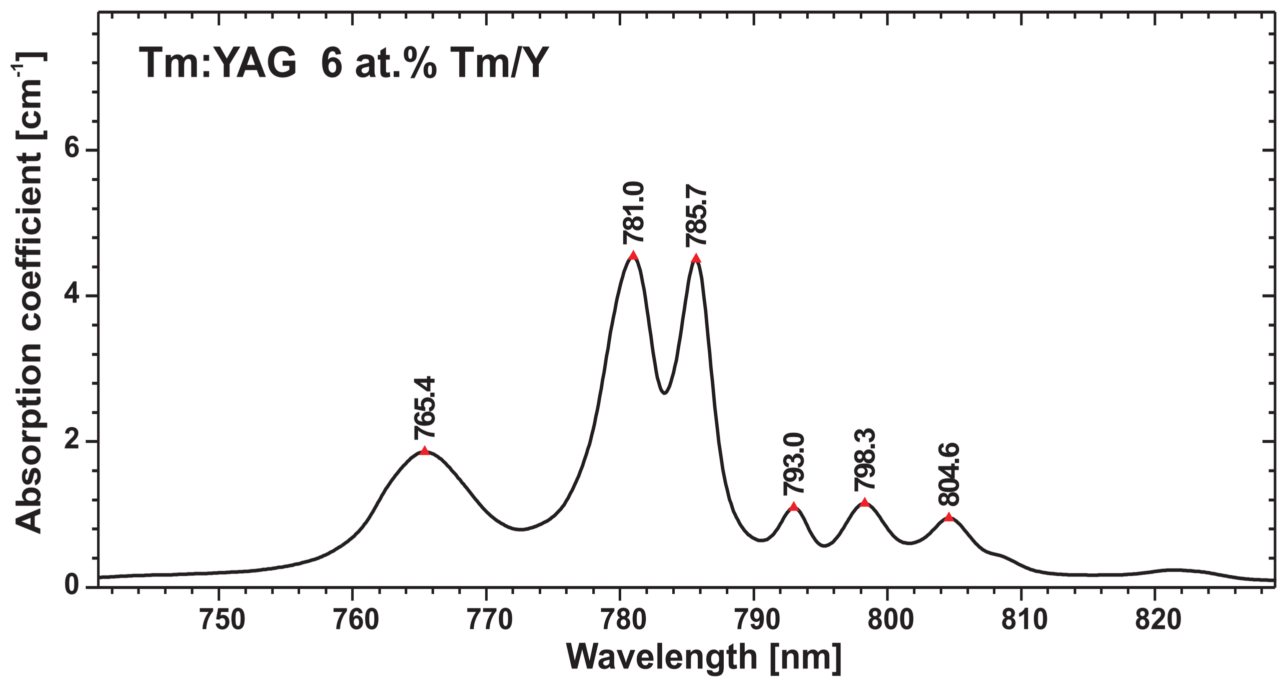
	A-cut	B-cut
Absorption peak	794.8 nm	793.5 nm
Absorption cross section	7×10^{-21} cm^2	
Emission wavelength	1980 nm	1940 nm
Emission cross section	5×10^{-20} cm^2	
Excited state lifetime	4.4 ms (6 % Tm)	





Tm:YAG

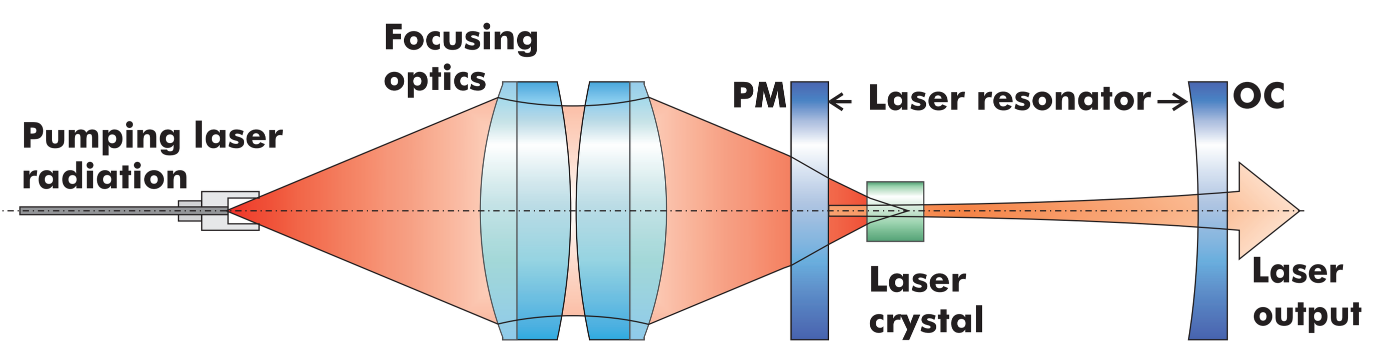




Tm:YAG fluorescent lifetime is about two times longer than of thulium in YAP. The emission cross-section in Tm:YAG is lower than in Tm:YAP. Tm:YAG is optically isotropic material.

Absorption peak	785 nm
Absorption cross section	7.5×10^{-21} cm^2
Emission wavelength	2013 nm
Emission cross section	2.2×10^{-20} cm^2
Excited state lifetime	9.2 ms (6 % Tm)

Experimental results

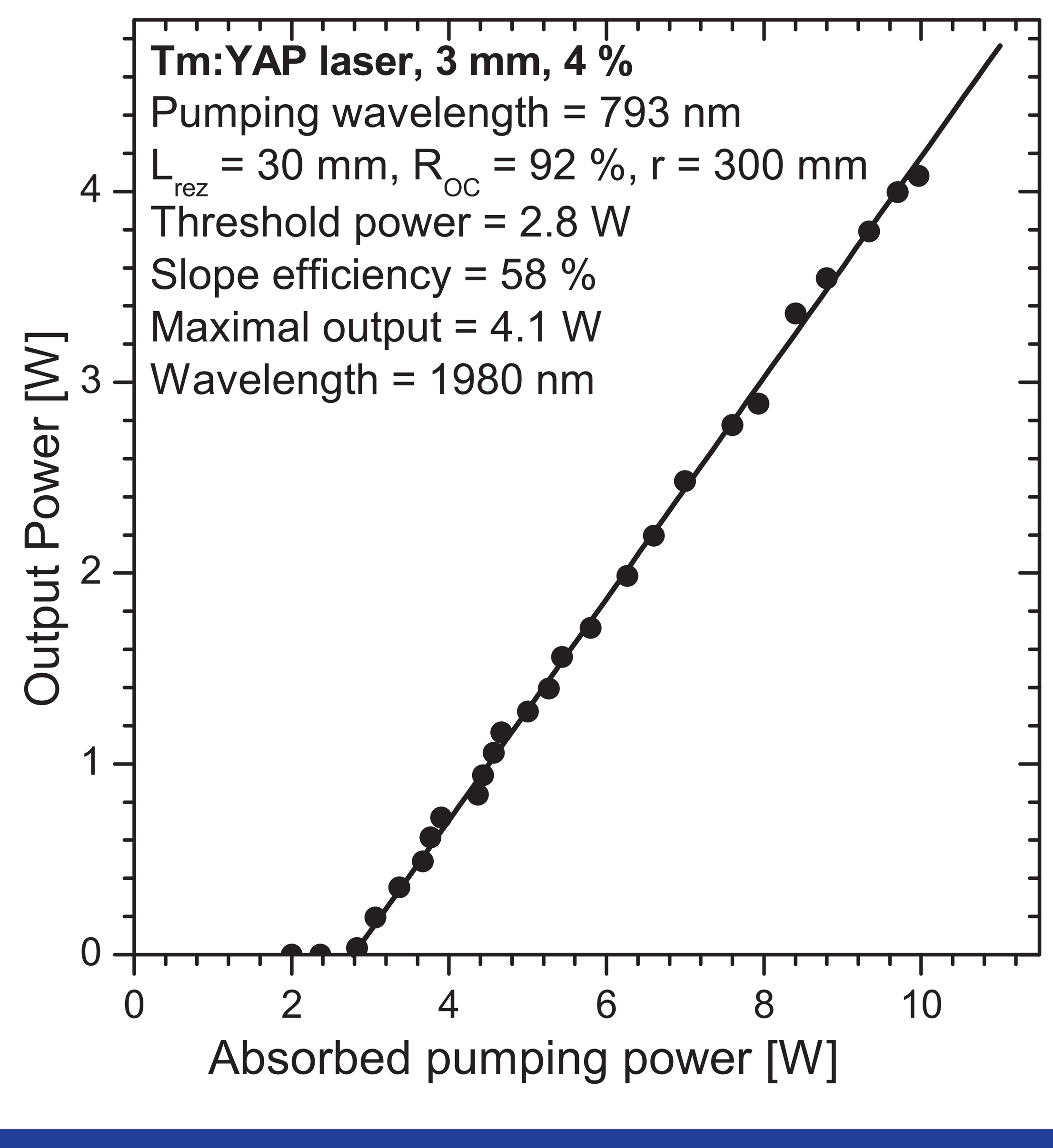


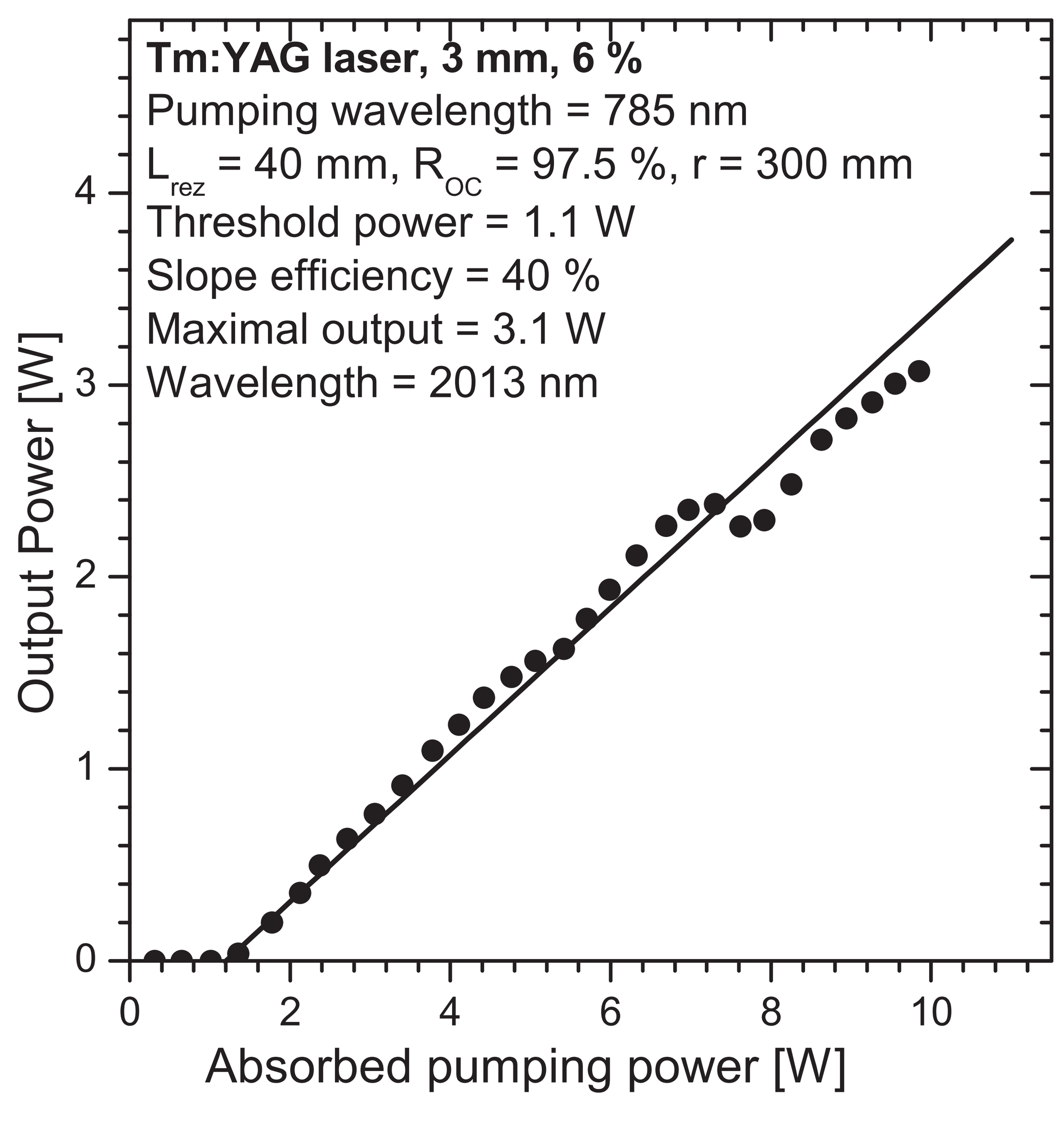
Pumping laser radiation
Fibre coupled diode HLU30F400-790 (LIMO)
Emission: 793 nm (Tm:YAP), 785 nm (Tm:YAG)
Fibre: D = 400 μm, NA = 0.22

Focussing optics 1:1
Two achomatic doublets, f = 75 mm, spot 380 μm

Laser crystal - AR/AR for pump & laser
Length = 3 mm, Diameter = 3 mm
Tm:YAP: c = 4 at.% Tm, Tm:YAG: c = 6 at.% Tm

Laser resonator
Length = 30 or 40 mm
RM: R = 100 % @ 1.8 - 2.1 μm, T_{MAX} @ 0.8 μm, flat
OC: R = 92 or 97.5 % @ 1.8 - 2.1 μm, r = 300 mm





Acknowledgment

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