Diode pumped cryogenic $Tm:Y_2O_3$ ceramic laser

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Abstract

Compact high average and peak power (HAPP) lasers emitting around two-micron have broad applications in various areas, such as laser induced damage threshold (LIDT) measurements, polymer material processing, debris removal from space, etc [1]. To achieve laser in two-micron region, Tm doped yttrium oxide ($Tm:Y_2O_3$) is a promising active media. The advantage of Tm ion is that it can be excited by commercial available AlGaAs laser diodes around 793 nm, and it also has two-to-one cross-relaxation process, which leads to much higher slope efficiency than the quantum defect limited value [2]. The host material, Y_2O_3 has very high thermal conductivity, a relatively low maximum phonon energy and sufficiently broad emission when doped with rare earth ions [3]. However, this material suffers from reabsorption losses due to quasi-three level system at room temperature and other parasitic process such as exited state absorption (ESA) and energy-transfer upconversion (ETU), which limit the power scaling and beam quality of laser. To mitigate these issues, cooling the active medium down to cryogenic temperatures is the proper solution. Here in this work, we studied the laser potentialities of this material at cryogenic temperature using Volume Bragg stabilized (VBG) diode laser emitting at 793 nm.

Cryogenic continuous wave laser operation is realized using a "L" shaped cavity with 3 at.% $Tm:Y_2O_3$ ceramic sample. Two parameters are varied: output coupler transmission (T_{oc} = 5, 9, 15, 20 and 30%) and sample temperature (80 – 180 K in step of 20 K), as shown in Fig. 1 (a) and (b), respectively. A maximum output power of 6.4 W is achieved at sample temperature of 80 K and T_{oc} = 30%, corresponding to a slope efficiency of 32.2%. The inset of Fig. 1 (b) shows a very high quality Gaussian beam profile obtained for incident power of 15 W.

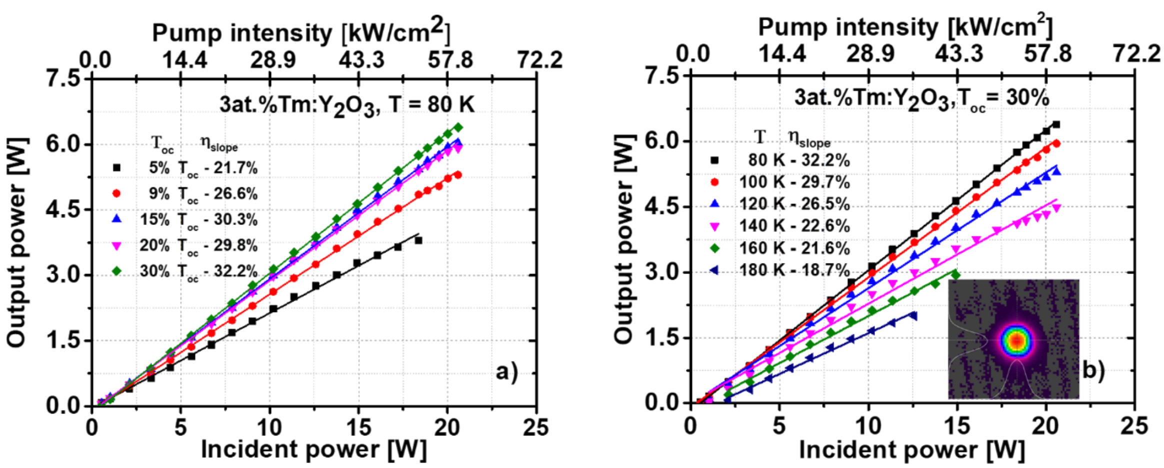

Fig. 1 Incident/output characteristics of 3 at.% $Tm:Y_2O_3$ ceramic pumped by 793 nm VBG diode (a) for various output couplers with sample temperature of 80 K and (b) for various sample temperatures with T_{oc} = 30%. Inset: Far field beam Gaussian profile under pump power of 15 W.

References

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