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Cryogenically cooled compact Yb:Lu_2O_3 laser

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In recent years, compact diode pumped solid-state lasers based on Ytterbium (Yb^{3+})-doped ions have attracted the scientific community due to their vast scientific and technological applications. Nevertheless, at room temperature, the Yb^{3+} doped gain materials behave as quasi three-level lasers, due to the finite population at ground state leading to reabsorption at laser wavelength and mitigate the power scaling capabilities. To overcome this issue and to enhance the output, the gain medium has to be cooled down to cryogenic temperatures, where four level is accomplished leading to an overall laser performance [1] . Many host materials have been studied in the past, here in this work we considered Lu_2O_3, which belongs to the cubic sesquioxides family. This host is known for its excellent thermal properties and it make it attractive for high power solid-state lasers [2].

The laser experiments were carried out in a compact modular cryogenic vacuum chamber that has the provision to mount the optics and sample as close as possible to form a compact laser cavity. As gain medium, an un-coated 5×5 mm^2 aperture and 3 mm thickness Yb: Lu_2O_3 ceramics of 1 at.% was used. It was mounted in a copper holder and was placed in between two mirrors to form a compact plano- plano cavity. For cooling down to cryogenic temperature, a two stage closed cycle cryostat having a heat load of 13 W at 100 K and to maintain the sample temperature, a 50 Ω heater connected near the cold finger were used. A VBG stabilized fiber coupled diode laser emitting at 976 nm with a spectral bandwidth of 0.40 nm (N.A. = 0.22, core diameter: 105 µm) was used as a pump source. The un-polarized pump beam was imaged using achromatic lenses with a ratio of 1:1.5.

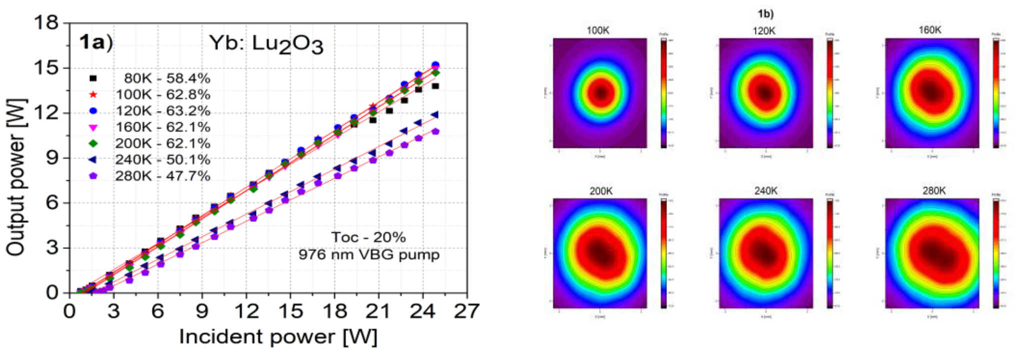

Fig. 1 (a) Input - Output power characteristics of 1. at.% Yb:Lu_2O_3 ceramic at different temperatures,T_{OC} = 20%; (b) Obtained beam profile for different temperatures at maximum power.

Continuous wave (CW) laser operation was realized for all the temperatures with 20% Toc in step size of 20 K from 80 K until 280 K. In all cases, the output power increases and the laser threshold decreases with decrease in temperature as shown in Fig. 1 (a). A maximum output power of 15.23 W for an incident power of 24.85 W was acheived for 120 K corresponding to a slope efficiency of 63% and the laser emits at 1031.6 nm. To be noted, from the results, although the output power and slope efficiency from 80 – 200 K were close as seen in Fig 1(a), but the beam profile changes from single mode to multi-mode (see Fig 1 (b)). From this, one can conclude that the cryogenic cooling has a huge impact on not only achieving better output but also on achieving a very good beam profile. Present work is focused on using other transmission of output coupling.

References

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