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Cheng, Haynes Pak Hay; Jensen, Ole Bjarlin; Petersen, Paul Michael; Andersen, Peter E.; Tidemand-Lichtenberg, Peter; Pedersen, Christian

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Tapered diode laser pumped 946 nm Nd:YAG laser

H.P.H. Cheng[1], O.B. Jensen[1], P.M. Petersen[1], P.E. Andersen[1], P. Tidemand-Lichtenberg[2], C. Pedersen[1]

1. DTU Fotonik, Technical University of Denmark, Frederiksborgvej 399, DK-4000, Roskilde, Denmark

2. DTU Physics, Technical University of Denmark, Fysikvej, Building 309, DK-2800, Kongens Lyngby, Denmark

Email : hach@fotonik.dtu.dk

We present a new and improved method for pumping three-level solid-state lasers. The better beam quality from tapered diode lasers makes them attractive pump sources in configurations that are inherently lossy; in particular, three-level laser systems. We present numerical calculations and experimental comparison of tapered diode laser pump performance against that of traditional broad area diode lasers (BAL).

In the first demonstration of DPSS laser at 946nm [1], Fan and Byer used a Rhodamine 6G dye-laser pump to extrapolate that a diode laser with good beam quality could achieve a conversion efficiency of at least 34% in terms of absorbed power in a 1.3mm Nd:YAG crystal. In a more recent demonstration, a 798nm tapered diode was used to pump a three-level Nd:ASL system, which achieved a slope efficiency of 34% and an output power of 156mW at 900nm [2].

Augé et al. presented a method to calculate the non-saturated gain per unit length in [3]. This approach is used here to compare a tapered diode laser and a BAL as pump sources for a 946nm Nd:YAG crystal. Figure 1 shows that tighter focus and lower divergence from a tapered diode lead to a higher gain that continues to outweigh reabsorption losses for longer crystal lengths, thereby increasing the overall conversion efficiency.

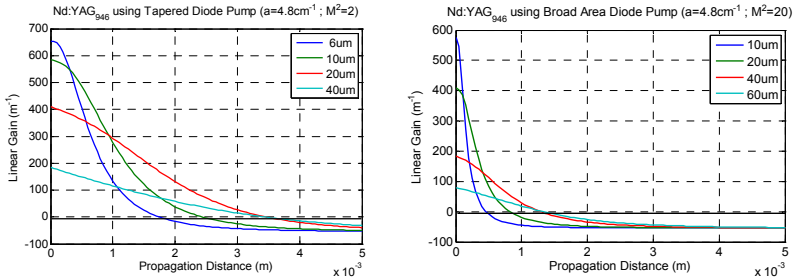

Fig. 1 Numerical calculation of non-saturated gain at 946 nm in Nd:YAG for tapered diode pump (left) and broad-area diode pump (right.)

We successfully implemented a 946 nm Nd:YAG laser based on a 808 nm tapered diode pump laser. The tapered diode is developed at the Ferdinand-Braun-Institute für Höchstfrequenztechnik in Germany. Figure 2 shows the experimental setup and results of each pump source coupled into a 1.5mm crystal and a 3mm crystal in a cavity with 3% output coupling. We failed to achieve lasing in the 3mm crystal with the BAL pump, but this was expected and agreed with numerical results. Absorption of the tapered pump is 84% and 63% for the 3mm and 1.5mm crystal respectively. A slope efficiency of 40% with respect to absorbed pump power was attained and a total output power of 700mW was reached, which to our knowledge is the highest reached with a single emitter diode pump source. In comparison with a BAL pumped laser, we show that tapered diode laser pumping potentially increase the power of 946 nm lasers by a factor of two and reduce the threshold by a factor of three.

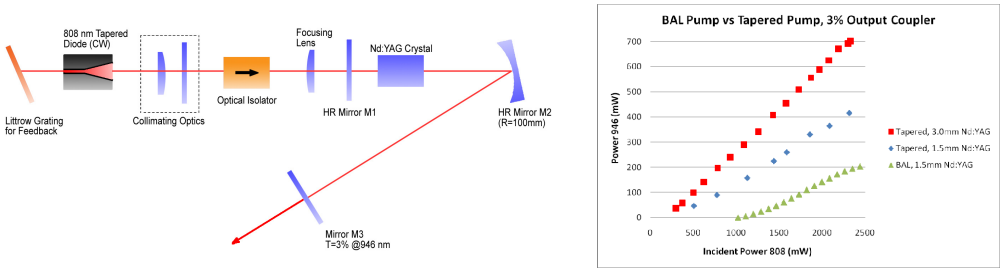

Fig. 2 Experimental setup (left) and results (right) of a 946 nm Nd:YAG laser pumped by a tapered diode laser and broad-area diode laser.

In conclusion, numerical and experimental results show that tapered diode pump sources are able to support longer crystal lengths in three-level systems, leading to increased overall efficiency.

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