cal issues at the interface, in general, will be beneficial to solid-state laser design activities. By implementing a design that achieves the goal of optimizing laser performance, a diamond-cooled laser will be better able to deliver even higher average power in a compact configuration with good beam quality.

6216-17, Session 4

Good beam quality from a diamond-cooled ErYAG laser

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Erbium doped YAG, lasing at 1645 nm from a 1532 nm pump, is an intriguing alternative to wavelength shifted 1-micron lasers for eye-safe applications. In this presentation, we will report on an end-pumped Er:YAG laser that employs diamond disks for heat extraction. Using an alternating arrangement of diamond and Er:YAG thin disks, heat flow is from the gain material to the diamond along the optical axis and then radially transmitted to a circulating cooling fluid at the perimeter of the diamond disks. This architecture allows larger diameter disks or rods to be used than conventional radial cooling architectures, thus allowing for higher powers through area scaling. This architecture also provides better beam quality for a given pulse energy. We have demonstrated excellent beam quality (M2=1.3) from a 10-Watt Er:YAG laser. We will also report on results of Q-switching and oscillator-amplifier experiments as well as a study of the well-known up-conversion process for relatively low dopant concentrations (0.5%-2.0% a.w. of Erbium).

6216-18, Session 4

Thermal management of solid state lasers using optical quality silicon carbide

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Heat removal from a solid-state active medium is a key issue for any high energy laser (HEL) development and often poses a major hurdle in laser power scaling. Recently, a promising power scaling approach has been proposed based on laser designs where efficient face cooling is achieved by interleaving thin layers of the active medium with an optically polished, highly thermally conductive diamond as heat-spreading material. It is expected, though, that the practical use of diamond will be hindered due to its high cost, limited optical quality and available size. Given the practical limitations of using diamond as a material for heat removal in SS lasers the material, Silicon Carbide (SiC), is proposed as diamond's replacement. Presented here are the modeling results indicating that even though SiC is four times less thermo-conductive than diamond, SiC optical heatspreaders are nearly as effective as diamond itself in reducing pump-induced thermal gradients. In support of these calculations, preliminary laser experimental results are presented as a proof of this approach and it is shown to be of great promise. We report that a water cooled laser using ceramic gain medium in a Nd:YAG/SiC/Nd:YAG, the "two-on-one" design, can operate with 25% slope efficiency, despite the Fresnel losses at the two intracavity SiC/Nd:YAG interfaces. The Nd3+ ion concentration was chosen to be 4 at.%. Thermal Finite Element Analysis (FEA) modeling results of the thermal distribution of the two-on-one Nd:YAG/SiC composite gain element design are presented and compared with the experimental heat distribution. We conclude that the interleaving of SiC with a SS gain medium works as a highly effective water cooled laser design and has great potential for simple area power scaling.

Based on our preliminary modeling and tests, we expect to be able to significantly boost the fast-developing "diamond-cooling" approach for the YAG-based SS laser power scaling relying on the latest developments in the domestic Silicon Carbide (SiC) industrial development.

6216-19, Session 5

Continuous-wave and mode-locked lasers based on cubic sesquioxide crystalline hosts

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Among the crystalline rare earth laser hosts the isotropic sesquioxides Sc2O3, Y2O3, and Lu2O3 (cubic bixbyite structure, space group T7h) are known for their superior thermo-mechanical properties. Their thermal conductivity considerably exceeds that of Y3Al5O12 (YAG). Their low phonon energy ensures large energy storage times by minimizing non-radiative relaxation processes. Yb-doped sesquioxides exhibit somewhat broader absorption and emission bandwidths than Yb:YAG which is advantageous for uncritical diode laser pumping and short pulse generation. The splitting of the lower Yb3+ manifold is also larger which is important in the quasi-four-level operation scheme. Solid solutions with the isostructural Yb2O3 are possible but the observed strong lifetime quenching makes the sesquioxide hosts more suitable for laser geometries that profit from relatively low Yb concentrations. Lu2O3 is the host whose thermal conductivity is least affected by Yb-doping. The high melting point (above 2400°C) makes it difficult to grow the sesquioxides from the melt. Recently, the use of the heat-exchanger-method (HEM) allowed to considerably enhance the optical quality of the grown crystals and the available single crystal size.

We will review laser results obtained recently with HEM-grown doped sesquioxide crystals in the continuous-wave (cw) and mode-locked (picosecond and femtosecond) regime using both Ti:sapphire and diode-laser pumping. In the cw regime pump efficiency of 62.2% and slope efficiency of 72.7% were reached with Yb:Sc2O3 operating at 1041.6 nm. Passive mode-locking of both Yb:Sc2O3 and Yb:Lu2O3 was achieved by semiconductor saturable absorber mirrors. Pulse durations of the order of 200 fs were obtained with intracavity dispersion compensation.

6216-20, Session 5

High-power diode-pumped laser based on Yb3+:Y2O3 ceramic

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Alternative laser host materials, Y2O3, Sc2O3, and Lu2O3, have the potential to offer much better average-power scalability than conventional YAG due to superior thermal and thermo-optic properties. These materials now are available in ceramic form, and some limited spectroscopic and laser characterization of Nd3+- and Yb3+-doped compounds has been done.

Reported here are laser characterization results of a high-power longitudinally diode-pumped polycrystalline Yb3+-doped Y2O3 ceramic laser. The pumping source was a fiber-coupled diode laser with emission at 937 nm and was run quasi-CW. Pump wavelength was chosen to be in the valley between the major absorption peaks, so that the results are less affected by the diode laser wavelength temperature instabilities. The Y2O3 ceramic laser sample (from Konoshima) was doped with 10 at. % of Yb3+. Due to the combination of high absorption cross-section and relatively high dopant concentration about 75% of the incident power is absorbed in the 1.67-mm thick gain medium. The laser cavity was formed by the dichroically-coated face of the laser sample and the concave (ROC 300 mm) external output coupler. Despite the limited quality of the Yb3+:Y2O3 ceramic sample available to us at this point, the output in excess of 26 W was obtained in our preliminary tests and is, to the best of our knowledge, the highest power reported so far for diode-pumped Yb3+-