Passively Q-switched microlaser based on structured laser gain-medium

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Passively Q-switched Nd^{3+}:YAG/Cr^{4+}:YAG lasers can be used for various applications such as laser ignition, frequency conversion and micromachining [1-2]. This requires over tens of milijoules of energy with pulse durations below several hundred picoseconds. Two technics then can be used to enhance the pulse energy while preserving the short pulse duration. First, one can increase the pumped area for storing more energy in the laser medium. The second solution is to rely on external amplification of the microchip output beam using the well-known MOPA scheme. In this work, we propose a new scheme for the end-pumped micro-laser, so called distributed face cooling (DFC), where the heatsink and small sections of gain elements are combined in a periodic fashion thanks to the surface activated bonding technology at room temperature. This design allows a basic pattern consisting of bonded Sapphire and Nd^{3+}:YAG crystals to be repeated, up to four times in our investigation. Due to such design, a flat temperature distribution along the crystal can be achieved. Also with the help of Sapphire heatsink the temperature radial gradient could be homogenized.

We applied surface activated bonding (SAB) technology, which was first applied in semiconductor industry for the wafer manufacturing [3]. Today this technology is useful in laser research for thermal management, by combining transparent heatsink material to gain crystal. Because it can be done at room temperature, materials with different thermal expansion coefficients can be combined without any post-bonding stress and high quality surfaces at the bonding interface. The bonding is based on covalent bonds between non-oxygen atoms, by pressing two crystals together.

For this work, we used two laser setups. The first laser setup was conventional end-pumped Nd^{3+}:YAG single crystal laser consisted. The laser diode was driven with 10 Hz repetition rate. The cavity consisted of single Nd^{3+}:YAG crystal rod with diameter 5 mm and thickness 4 mm. A Cr^{4+}:YAG crystal was used as saturable absorber (SA). The small signal gain of SA was equal to 50%. Finally, mirror with reflection equal to 70% was used as an output coupler (OC). The laser output was equal to 10.2 mJ with pulse duration of 350 ps and peak power equal to 29.2 MW. Although peak power achieved is high, the beam profile was poor. This can be attributed to a strong thermal degradation during the pumping.

Second setup shown in Fig. 1, consisted of a distributed face cooling structure comprised of Sapphire crystal bonded to the Nd^{3+}:YAG crystal. Both Sapphire and gain crystal had length equal to 1 mm. Four pieces of Sapphire and four pieces of Nd^{3+}:YAG crystals were used in combination to produce eight-piece structure. The small signal gain of SA was equal to 30% and OC mirror with reflection equal to 40% was used. The laser output was equal to 9 mJ with pulse duration of 815 ps. This longer pulse duration is the consequence of longer cavity length we used for the second setup. The peak power in this case was equal to 11 MW. During this operation, the output beam profile quality was greatly improved compared to the case of single crystal.

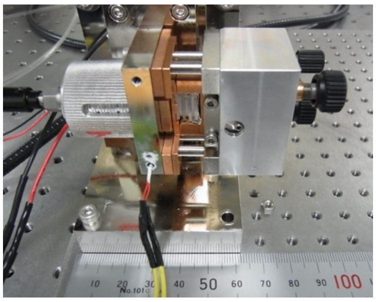

Fig. 1. Passively Q-switched microlaser with DFC structure consisting of eight crystals.

Further development of this lasers will be improvement of bonding technology, optimizing the microlaser to scale-up the performance and implementing such structure for the amplifier system in MOPA configuration.

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References

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