Laser Pulse Control of a Q-switched Nd:YVO_4 Bounce Geometry Laser using a Secondary Cavity

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Pulsed laser operation is desirable for a wide range of applications such as laser micromachining in industrial manufacturing and laser marking for product identification [1]. In these cases it is beneficial to have flexibility in the parameters of the laser pulse to suit the specific application. This can include the ability to achieve a wide range of pulse repetition rates, with some applications requiring variation of laser pulse rate from high rate (multi-kHz) to low rate or even an off-state in a fast timescale. To generate ultrahigh pulse rates requires Q-switched lasers with ultrahigh gain, but problems can arise if the modulation element is insufficient to prevent laser action or hold-off lasing at low repetition rates. In these cases, lasing output can occur when it is not desired [2]. In this work we present a novel method for pulse control in a high gain bounce amplifier Q-switched system by using a secondary cavity to clamp the gain and allow for clean single pulse operation from very high (800kHz) to very low (e.g.1kHz) repetition rates.

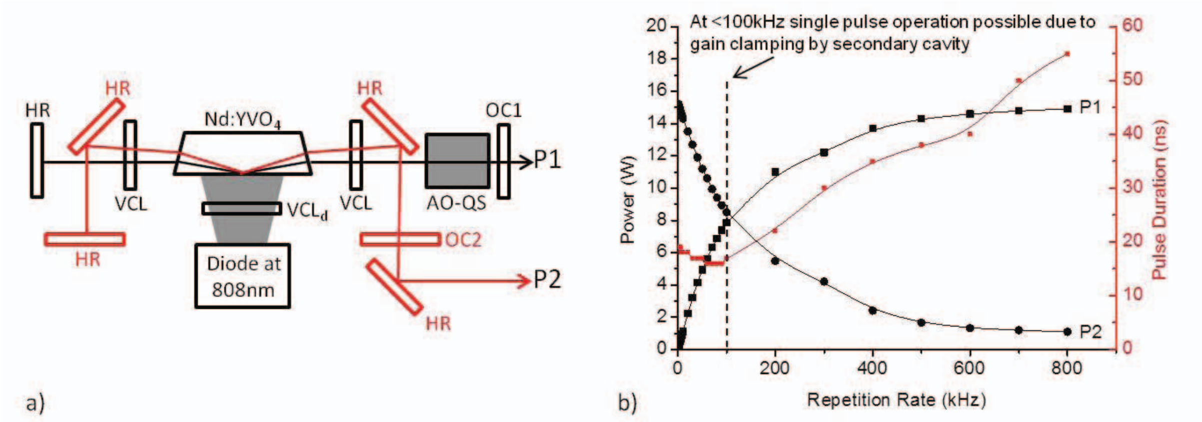

Fig. 1. (a) Schematic of diode pumped Nd:YVO_4 laser in the bounce geometry (b) Power curve for primary (P1) and secondary (P2) cavities and Q-switched pulse duration for a range of repetition rates at pump power of 37W.

A schematic of the experimental system is shown in Fig. 1(a). This set-up utilised the bounce geometry in which the laser mode takes a total internal reflection off the pump face of the laser crystal. The laser crystal was a 1.1at. % doped Nd:YVO_4 slab crystal with dimensions of 20mm x 5mm x 2mm. Side pumping was achieved via the 20mm x 2mm face using a 50W diode bar operating at 808nm. Two laser cavities, a primary cavity with output P1 and a secondary cavity with output P2, were formed using the same laser crystal. The path of the primary cavity mode (shown by the black line in Fig. 1(a)) includes an acousto-optic Q-switch (AO-QS) for pulsed operation. A secondary cavity, with a slightly larger internal bounce angle is shown in red and its threshold can be set by its cavity optics.

With the secondary cavity blocked, 26W of Q-switched output at a repetition rate of 800kHz was achieved in TEM_{00} mode at a pump power of 50W from the primary cavity. In this scheme it was not possible to achieve clean pulsed operation at repetition rates below ~100kHz as the Q-switch could not effectively hold off lasing. With the secondary cavity operating, the gain could be clamped at a level that the Q-switch was able to suppress. The effect of this is seen in Fig. 1(b) which shows the Q-switched pulse duration and output power (P1) from the primary cavity alongside the output power (P2) from the secondary cavity for repetition rates ranging from 1-800kHz at a pump power of 37W. At 800kHz, an output power of 15W was obtained from the primary cavity. Decreasing the repetition rate led to a decrease in P1 and a corresponding increase in P2. Although this suppression of the primary cavity resulted in lower average power and Q-switched pulse energy, it allowed clean single pulse operation to be achieved at all repetition rates shown. In addition, at repetition rates below 100kHz, the Q-switched pulse duration is almost constant at ~18ns due to the clamping of the gain.

References

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