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Short-Pulse Generation in a Diode-End-Pumped Solid-State Laser

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INTRODUCTION

A $Nd:YVO_4$ modelocked laser has been constructed using a resonator designed according to the theoretical parameters. The laser produced pulses in the picosecond region with a maximum average output power of 2.8W. Passive modelocking of the $Nd:YVO_4$ laser has been demonstrated using a semiconductor saturable absorber mirror (SESAM).

THEORETICAL ANALYSIS

Ultra-fast solid state lasers are a key component for many applications which require lasers at high repetition rates in the MHz range. A $Nd:YVO_4$ laser has been developed utilising a semiconductor InGaAs quantum well saturable absorber for passive mode-locked operation. A theoretical analysis of the optimum resonator parameters required to achieved a stable cw-modelocking regime was performed and this is described by equation [1]

$$E_{p,\mathrm{int}}^{2} > E_{L,sat} E_{A,sat} \Delta R \qquad (1)$$

where $E_{p,\mathrm{int}}$ is the intracavity pulse energy, $E_{L,\mathrm{sat}}$ the gain saturation energy, $E_{A,\mathrm{sat}}$ the absorber saturation energy and ΔR the absorber modulation depth. By solving Equation 1, the cavity length as well as beam diameters on crystal and on saturable absorber were established for the best compromise between performance and a low transition between the *Q*-switched modelocking and continuous modelocking regimes represented by Fig.1 which occur when:

$$P_{QSML,th} = K T_{OC} \frac{w_L w_A}{L} \sqrt{F_{sat,A} \Delta R} \;, \qquad (2)$$

Where $K=\sqrt{(\pi^2 hc^3 / (4m\sigma_L \lambda))}$, $P_{QSML,th}$ the *Q*-switched modelocking transition output power of the laser, T_{oc} the output coupler transmission, w_L beam width in the crystal, w_A beam width on the absorber, L resonator length and $F_{A,\mathrm{sat}}$ the saturation fluence on the absorber.

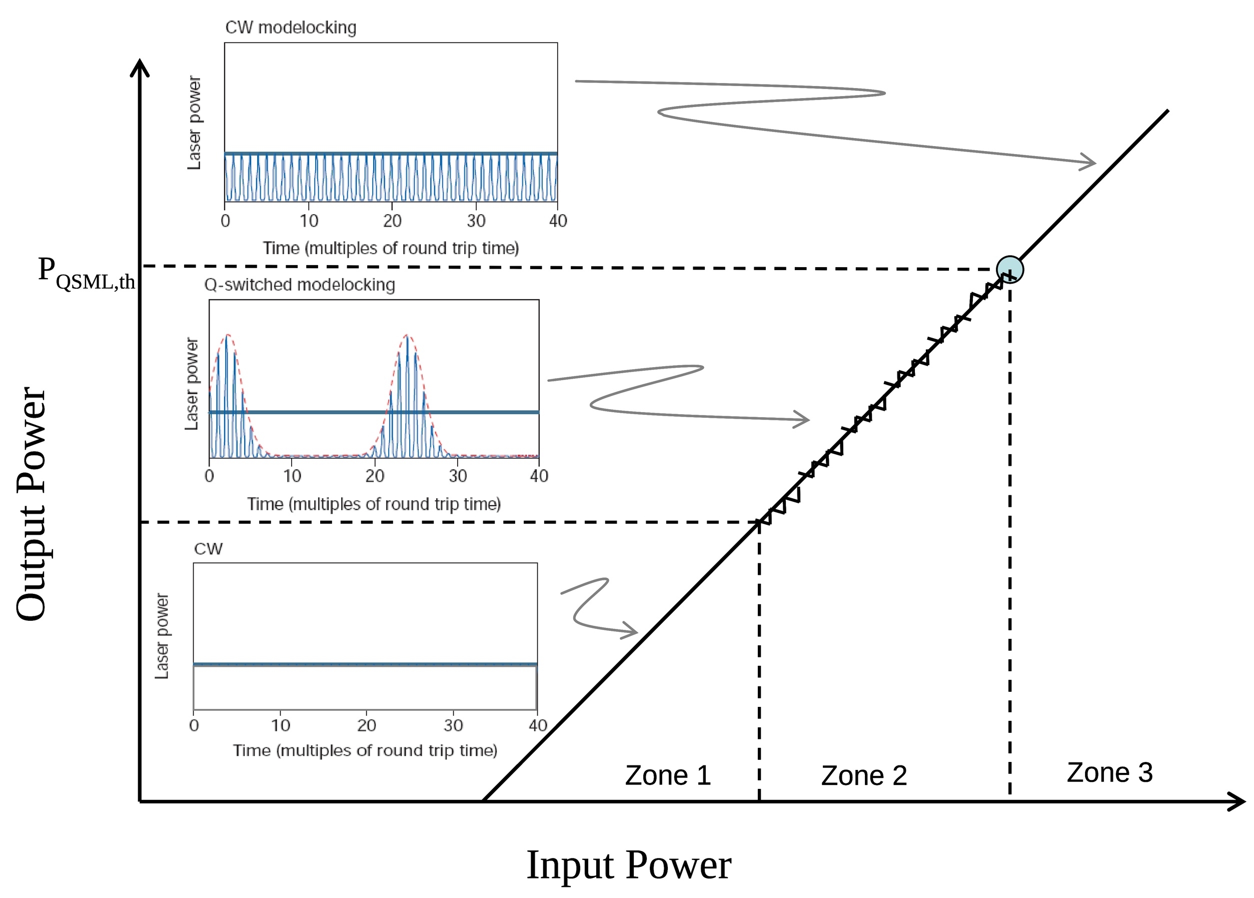

Figure 1: Output power of a SESAM modelocked laser verses input power; showing three different modelocking regimes of cw, *Q*-switched modelocked and the cw-modelocked.

EXPERIMENTAL SETUP & RESULTS

The designed resonator T_{oc} was 35% at 1063nm shown as M1 in the schematic diagram in Fig. 2a. The mirror M2 acted as a folding mirror, while M3 and M4 extended L to 825mm. The $E_{L,\mathrm{sat}}$ was 118µJ when using w_L of 250µm. The $F_{A,\mathrm{sat}}$ was 10nJ andthis resulted to an $E_{A,\mathrm{sat}}$ of 1.0nJ when using w_A of 170µm on M5. The calculated $E_{p,\mathrm{int}}$ was 32.7nJ and this resulted to a theoretical $P_{QSML,th}$ of 2.08W.

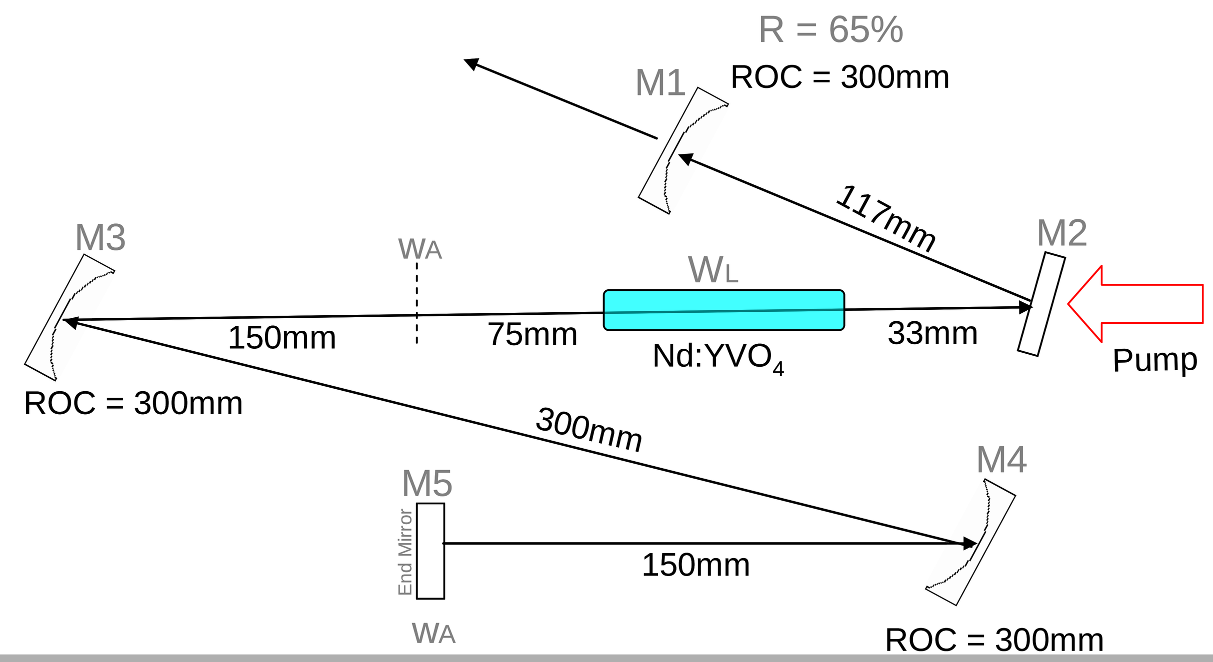

Figure 2a: Schematic diagram of the 1:1 relay system laser resonator with a cavity length of 825 mm.

The experimental laser setup is shown in Fig.2b and the laser produced cw-modelocked pulses with frequency of 179MHz which are equivalent to the cavity round trip time of 5.6ns, as shown by Fig. 3(a).

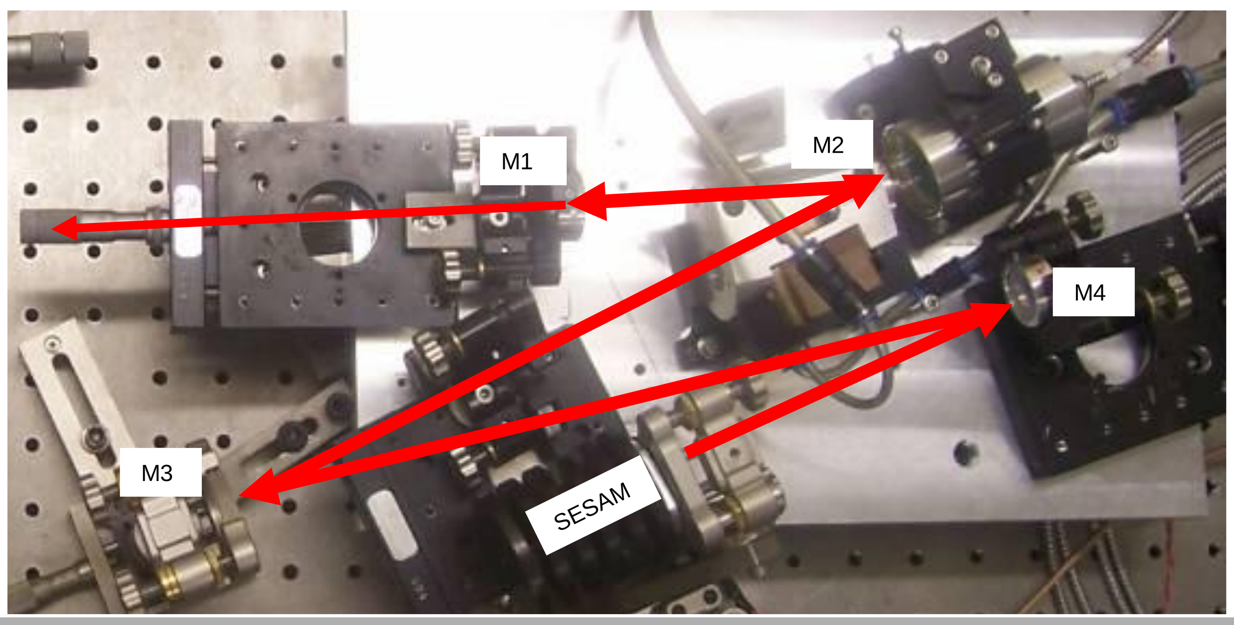

Figure 2b: The photograph of the laser in the laboratory

The $P_{QSML,th}$ of the laser was 2.8W which represented pulse fluence (F_A) on the SESAM of 49.3µJcm^{-2}. The difference between the calculated and experimental $P_{QSML,th}$ was due to the saturation fluence of the SESAM ($F_{A,\mathrm{sat}}$) being sensitive to temperature changes as shown by Fig 3(b). The pulse duration were not measured but are estimated to be 10-20ps since identical SESAM were used by Dr Erwin Bente for modelocking a Nd:YLF laser which emitted pulses with a duration of 21ps [2]. The extra oscillation between the pulses was due to mis-alignment of the laser [2].

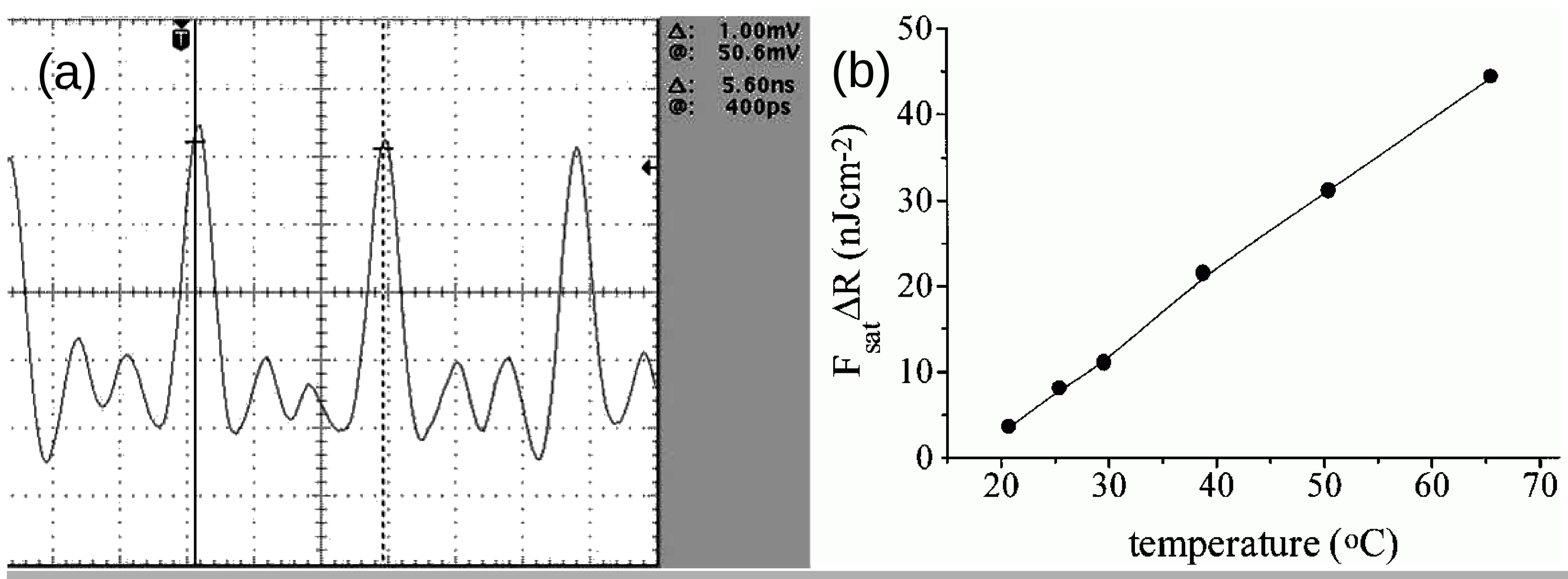

Figure 3: (a) Cw modelocking using a SQW SESAM and (b) Graph of $F_{sat,A}\Delta R$ of the SESAM verses temperature [2].

REFERENCES

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