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

INTRODUCTION
A Nd:YVO₄ 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:YVO₄ 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:YVO₄ 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 achieve a stable cw-modelocking regime was performed and this is described by equation (1)

\[ F_{p,\text{int}}^2 > F_{L,\text{sat}} F_{A,\text{sat}}^\Delta R \tag{1} \]

where \( F_{p,\text{int}} \) is the intracavity pulse energy, \( F_{L,\text{sat}} \) the gain saturation energy, \( F_{A,\text{sat}} \) the absorber saturation energy and \( \Delta R \) 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 mode-locking and continuous modelocking regimes represented by Fig.1 which occur when:

\[ F_{P,\text{Q-switch}} = K T_{oc} n_{w} A_{w} \sqrt{F_{A,\text{sat}}/\Delta R} \tag{2} \]

Where \( K = \left(\pi^2 n^2 c^2 / \left(4\alpha_{\text{crystal}}\lambda\right)\right) \), \( F_{P,\text{Q-switch}} \) the Q-switched modelocking transition output power of the laser, \( T_{oc} \) the output coupler transmission, \( n_{w} \) beam width in the crystal, \( w_{A} \) beam width on the absorber, \( L \) resonator length and \( F_{A,\text{sat}} \) the saturation fluence on the absorber.

Experimental Analysis & 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 825nm. The \( E_{\text{sat}} \) was 118μJ when using \( w_{L} \) of 250μm. The \( F_{p,\text{int}} \) was 10nJ andthis resulted to an \( E_{A,\text{sat}} \) of 1.0nJ when using \( w_{A} \) of 170μm on M5. The calculated \( E_{\text{sat}} \) was 32.7nJ and this resulted to a theoretical \( P_{\text{Q-switch}} \) of 2.08W.

EXPERIMENTAL SETUP & RESULTS
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REFERENCES

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.