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FEEDBACK-CONTROLLED PRELASING: A TECHNIQUE FOR PULSE AMPLITUDE AND FREQUENCY STABILISATION OF Q-SWITCHED LASERS

C. Bollig, S. D. Butterworth, W. A. Clarkson and D. C. Hanna
Optoelectronics Research Centre, University of Southampton, Southampton SO17 1BJ

A reliable single-frequency Q-switched laser with high pulse repetition frequency (PRF) and good pulse to pulse stability is desirable for many applications, including those where a high average power is required.

One popular approach for obtaining single-frequency operation of Q-switched lasers is to use the technique of prelase Q-switching, where a low power single-frequency oscillation is established prior to opening the Q-switch. In practice this technique has been limited to low PRFs (typically $\leq$ 1kHz) since the prelase usually begins with strong spiking behaviour followed by relaxation oscillations. These take a time to decay to the steady prelase required for reliable single-frequency operation and high pulse to pulse stability. At high PRFs, when the Q-switched pulse builds up from prelase spikes, large fluctuations in pulse amplitude and excessive timing jitter occur. In this paper we report a new technique involving actively controlling the diffraction loss of the Q-switch, so as to damp out spiking and relaxation oscillation. We have applied this technique to a Nd:YAG ring laser, pumped by a 1.2W high-brightness diode, in which a single acousto-optic modulator enforces unidirectional operation and is used to Q-switch the laser.

To control the prelase power we have monitored the power in the diffracted beam, and using a simple PID (proportional-integral-differential) control unit to control the RF power and hence diffraction loss of the A-O Q-switch to hold the prelase power at an adjustable preset level. The spiking is then damped and as a result the establishment of a unidirectional and single-frequency prelase occurs sooner. The stable and reliable prelase results in much reduced pulse to pulse amplitude and timing fluctuations. This technique made it possible to increase the PRF of a prelase Q-switched laser from less than 1kHz up to 25kHz maintaining high pulse to pulse stability. At these higher PRFs up to 88% of the available cw output was available in the Q-switched output.

The very stable prelase can also be used to frequency stabilise the Q-switched pulses by locking the prelase to an external stabilized Fabry-Perot etalon, a procedure which would be problematic with a fluctuating prelase. By locking the prelase to the etalon every pulse is stabilized individually rather than averaging over several pulses and compensating long term drifts.

We have used the diffracted beam of the A-O Q-switch to lock the prelase to a temperature controlled solid glass etalon of 17mm length (i. e. FSR = 6GHz) by locking to the slope of the transmission peak. The temperature of the laser rod was also stabilized in order to control the drift of the gain peak. Details of the frequency stabilised performance will be described in the paper.

The technique of prelase stabilization offers a simple and attractive route to reliable single-frequency operational high PRF devices, with the capability of being scaled to much higher powers using diode-bar pumps and allowing, via harmonic generation, stable, single-frequency generation at high powers in the visible/UV.