VERSATILE INFRARED LASER SOURCE FOR LOW-COST ANALYSIS OF GAS EMISSIONS

DELIVERABLE D1.6

Widely-tunable pulsed Tm-doped fibre Master-Oscillator Power-Amplifier (MOPA)

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1. BACKGROUND AND PROGRESS

The motivation for exploring pulsed operation of the Tm-doped fibre MOPA is to achieve higher peak power than can be achieved for a cw MOPA for the same pump power and thus be able to operate a singly-resonant optical parametric oscillator (SRO) based OP-GaAs in quasi-cw mode. The threshold pump power for a continuous-wave OP-GaAs SRO is estimated to be in the region of 50 – 80 W taking into account current values for loss and effective nonlinear coefficient for the OP-GaAs samples. The threshold pump power for an SRO operating in quasi-cw mode is approximately the same as for a cw SRO providing that the pump pulse duration is long enough to allow a sufficient number of round-trips of the SRO cavity for the power to build up and hence for oscillation to be established. The pump pulse duration required depends on the parametric gain, cavity loss and cavity round-trip time. For most situations of interest, the required pump pulse duration is expected to be in the region of 1 µs or longer. Earlier work on pulsed operation of Tm-doped DFB lasers (described in report D1.4) investigated the use of gain-switching as a means to produce the required pulse durations. Our work confirmed that gain-switched operation of Tm DFB fibre lasers offered an attractive route to higher peak powers than can be achieved in cw mode, but the pulse durations were typically < 100 ns and hence far too short for quasi-cw pumping of an SRO based on OP-GaAs.

As a rough guide, the pulse duration for a gain-switched fibre laser varies with core diameter, D and resonator length, L according to:

$$\tau_p \propto D\sqrt{\frac{L}{P_p}}$$

where P_p is the absorbed pump power. Thus, to increase the pulse duration we need to employ a longer resonator and/or a Tm fibre with a larger core diameter. In the case of a DFB laser configuration it is extremely difficult to increase the cavity length and/or core diameter, so this approach was not considered viable.

An alternative approach is to use a Distributed Bragg Reflector (DBR) cavity configuration with a very long resonator length. Preliminary experiments on a simple fibre laser with an external feedback cavity configuration indicted that pulse durations ~ 1 µs could be achieved using a fibre length of ~ 30 m. However this approach has the drawback that narrow-linewidths (as required by the Village project) would be difficult to achieve. Studies aimed at further investigation of this approach have been conducted to assess its viability. In particular, a relatively long DBR laser configuration was constructed and evaluated. The laser comprised a fibre-Bragg-grating (FBG) in a passive section of fibre spliced to a Tm-doped fibre (see Fig. 1). Feedback for lasing was provided by the FBG and the ~4% Fresnel reflection from a perpendicularly-cleaved facet in the Tm fibre at the opposite end of the laser. Using the tuning arrangement developed for the DFB laser, we could tune the operating wavelength over 33 nm from 1906 nm to 1939 nm. Further extension of this tuning range should be possible. The linewidth was ~ 0.35 nm (FWHM) corresponding to a frequency width of 27 GHz. Reduction of this linewidth by a factor-of-ten should be possible by using a much longer FBG, but this would still be over an order-of-magnitude too wide for the Village project application.

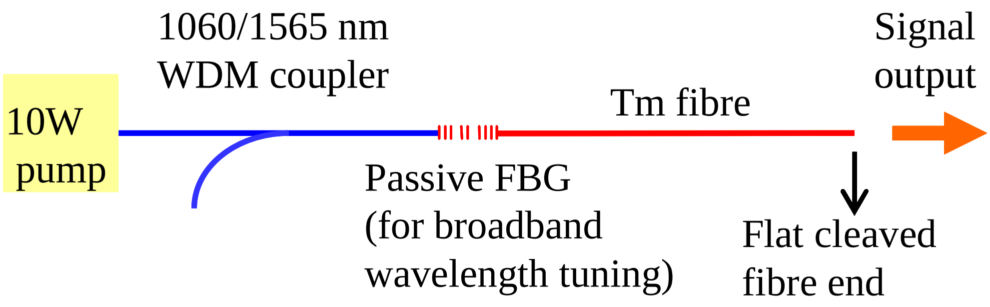

Fig. 1: DBR laser configuration.

2. CONCLUSION

In conclusion, gain-switched operation of a DBR laser with a long cavity length offers a route to the required power levels and pulse durations for quasi-cw operation of an SRO, but it does not appear to provide a route to the narrow-linewidths (<50 MHz) required by Village. No corresponding prototype is therefore worth delivering to NEO or HHUD. An alternative, but more complicated strategy for achieving long pulse operation is via gating the cw output from the DFB laser plus pre-amplifier prior to final amplification in the power amplifier stage using an acousto-optic modulator. It is likely that some pre-shaping of the pulse will be required to compensate pulse distortion due to gain saturation in the amplifier. Investigation of this approach can only commence when the remaining problems with the DFB laser are solved. Further work on the pulsed source will therefore take a low priority in favour of a more focussed effort on the development of widely tunable cw MOPAs, which are required by HHUD and NEO. However, when this work is complete, it should be possible to modify the cw MOPA architecture by inclusion of an acousto-optic modulator to allow operation in long-pulse mode. This is a possibility that we are very keen to explore as it still offers an attractive route to a mid-IR SRO based on OP-GaAs.