13.15 CMG9

Passively Q-switched single-frequency Nd:YAG ring laser with feedback and phase conjugation

P. P. Pashinin, E. J. Shklovsky, V.V. Tumorin, General Physics Institute, 38 Vavilov str., Moscow, Russia, fax: (095) 135 20 55, e-mail: shklov@kapella.gpi.ru
C. -Y. Tang, Tamkang University, Tamsui 25137, Republic of China, fax: 886-22-6221523

Q-switched Nd:YAG lasers producing narrow-linewidth pump beams are imperative for efficient and reliable operation of diverse devices based on nonlinear optical conversion, such as harmonic generators, optical parametric oscillators etc. At present injection seeding[1] is considered to be the most advanced method to produce single-frequency oscillation in Q-switched solid-state lasers. However the injection seeded systems are rather complicated as they virtually employ two lasers: low power, frequency-stabilized, narrow-bandwidth oscillator and a regenerative amplifier. Alternative optical schemes based on ring resonator arrangement, being much simpler, suffer from relatively low pulse energy, usually 10...20 mJ. Besides some promising ring arrangements are poorly investigated with respect to pulse-to-pulse energy/shape stability.

In our research we have studied a number of ring laser configurations with optical feedback. The important property of these is that unidirectional lasing can be sustained within a substantial change of feedback coupling. Even 10% feedback was enough for stable lasing of ripple-free pulses (Fig.1).

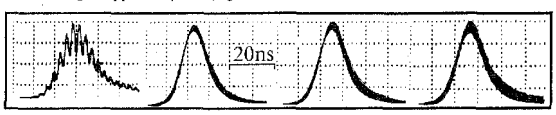

Fig.1. Oscilloscope traces of the recorded laser pulses.
No feedback, single pulse (a), with feedback: 160 pulses overlapped (b), 320 pulses overlapped (c), 640 pulses overlapped (d)

Lower feedback resulted in more often mode beats in the output pulses. We found experimental arrangements for which the modulation was less than 5% for 99% of pulses with pulse-to-pulse energy stability within +/-5% for thousands of shots. The effect of sustaining single-frequency lasing by a high transmission mirror, serving as the feedback, extends opportunities of ring lasers. In particular additional energy extraction is achieved in the scheme which incorporates glass etalon (both surfaces being uncoated) as the feedback, phase conjugation mirror positioned behind the etalon, and Faraday rotator serving for rejection of the laser pulse from the ring resonator. The oscillator based on this design produced single-frequency, near diffraction limited radiation with energy up to 200 mJ in a 12-ns pulse at 20 Hz.

The computer model, in which rate equations for passive Q-switching and transient effects in the phase-conjugator were used, adequately describes the experimental results.

1. Y. K. Park, G. Giuliani, and R. L. Byer, "Stable single-axial-mode operation of an unstable-resonator Nd-YAG oscillator by injection locking", Opt. Lett., vol.10, pp. 65-67, 1985.

11.00-13.30 CMH - Vertical Cavity Surface Emitting Lasers
Presider: A. Larsson, *Chalmers University of Technology, Göteborg, SWEDEN*

LOMOND

11.00 CMH1 (Invited)

Long Wavelength Vertical Cavity Lasers

K.Streubel* and M.Hammar
Department of Electronics, Royal Institute of Technology, S-164 40 Kista, Sweden
*Mitel Semiconductor AB, S-175 26 Järfälla, Sweden

Long-wavelength Vertical Cavity Lasers (VCLs) emitting at 1300 or 1550nm are considered as promising candidates as low-cost light sources in fiber optical communication systems. Despite the success of their short-wavelength counterparts, and even the demonstration of well-above room temperature continuous operation of a double-fused VCSEL at 155nm /1/, their final demand on mirror reflectivity (>99.5%), uniform current injection and exact gain-cavity tuning, is even further pronounced in the long wavelength regime. This is mainly due to excessive losses (intervalence band absorption, Auger recombination and diffraction) and a relatively small refractive index difference in the InGaAsP/InP system. To overcome these problems, several generically different designs have been presented and investigated. The so far most successful approaches use at least one wafer fusion step to combine an InGaAsP active layer with one or two AlGaAs/GaAs DBRs. However, such solutions are rather complex from a processing point of view, not yet demonstrated as full two-inch compatible. A more attractive design in this respect is based on the combination of an InGaAsP/InP bottom DBR and a dielectric top mirror. So far such lasers have been limited to low-temperature operation /2/, but significant improvements can still be expected from a better optimized current injection scheme or improved dielectric mirror quality. Alternative approaches, e.g., based on GaInNAs lattice matched to GaAs as active material may also become of importance.

In this contribution, we compare the design and characterization of some different InGaAsP-based long-wavefength VCLs involving zero, one or two wafer fusion steps. We are thereby able to identify key parameters important to device performance, especially elucidating the role of the mirrors and a homogeneous current injection. We also detail critical processing steps for realizing long-wavelength VCLs such as wafer fusion, selective AlGaAs-oxidation and epitaxial semi-insulating regrowth around the laser mesas.

References

/1/ N.M.Margalit, J.Piprek, S.Zhang, D.I.Babic, K.Streubel, R.P.Mirin, J.R.Wesselmann, J.E.Bowers and E.L.Hu, *64°C Continuous-Wave Operation of 1.5μm Vertical-Cavity Laser*, IEEE J. Select. Topics in Quant.Electron. 3 (2) 359 (1997)

/2/ S.Rapp, J.Piprek, K.Streubel, J.Andre and J.Wallin, *Temperature Sensitivity of 1.54-μm Vertical Cavity Lasers with an InP-based Bragg Reflector*, IEEE J.Quant.Electr. 33 (10) 1839 (1997)