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Wavelength stabilisation during current pulsing of tapered laser

O.B. Jensen

The use of external feedback to stabilise the frequency of a tapered laser during current pulsing is reported. Using this technique more than 20 W of peak power in 60 ns pulses from the tapered laser is obtained and owing to the external feedback, the laser is tunable in the 778–808 nm range. The spectral width of the tapered laser is significantly narrowed compared to the freely running laser.

Introduction: High power tapered diode lasers are interesting light sources for a wide range of applications including spectroscopy, as pump sources for solid state lasers, and for frequency conversion [1–3]. For instance within fluorescence diagnostics, light with wavelengths in the blue or UV (ultraviolet) are required and a pulsed light source is beneficial for suppression of the backlight. One relatively simple route to the efficient generation of blue light is by direct frequency doubling of a diode laser [3]. The conversion efficiency of the frequency doubling process is dependent on the input power level and the spatial and spectral properties of the input beam. In order to increase the input power without increasing the facet load of the diode laser, pulsed operation of the diode laser is a possibility. An improvement of the spectral properties of the laser can be obtained by the use of an external cavity arrangement. Furthermore, the spatial properties of tapered diode lasers are significantly improved compared to broad area lasers. Frequency locking and wavelength tuning of a current pulsed external cavity broad area laser diode has been demonstrated with 10 nm tuning range at a peak power of 25 W [4]. Recently, a current pulsed external cavity laser system based on tapered gain media has been demonstrated at 671 nm with up to 5 W peak power at a fixed wavelength [5].

In this Letter, a current pulsed grating tuned external cavity tapered diode laser around 800 nm based on a tapered amplifier is demonstrated. A peak output power of more than 20 W and a tuning range of 30 nm have been demonstrated with significant narrowing of the optical spectrum making it an attractive source for frequency conversion. To the best of our knowledge this is the first demonstration of a tunable current pulsed external cavity tapered diode laser system.

Experimental setup: The pulsed tapered diode laser system is shown schematically in Fig. 1. The c-mounted tapered amplifier used in our experiments is based on a super-large optical-cavity [6] ensuring a low vertical divergence of 18° (FWHM). The amplifier, similar to the one used in [3], consists of a 1 mm-long index guided ridge waveguide with a width of 3 μm and a 3 mm-long gain-guided tapered section with a taper angle of 4°. The amplifier is anti-reflection coated on the rear facet ($R < 0.1\%$) and on the front facet ($R = 0.5\%$) for operation in an external cavity. The output from the rear facet is collimated using a 3.1 mm focal length aspheric lens with a numerical aperture of 0.68 and incident on a Littrow-mounted ruled diffraction grating with 1200 grooves/mm. The output from the external cavity laser is collimated in the fast axis using a 3.1 mm focal length aspheric lens with a numerical aperture of 0.68 and the astigmatism is compensated for with a cylindrical lens with 40 mm focal length. The tapered amplifier, the two aspheric lenses and the grating are mounted on a temperature stabilised base plate to increase the stability of the setup. A commercial pulsed laser diode driver (Avtech AV-107D-B) is used to drive the laser in pulsed operation with a pulse width of 60 ns and 500 Hz repetition rate.

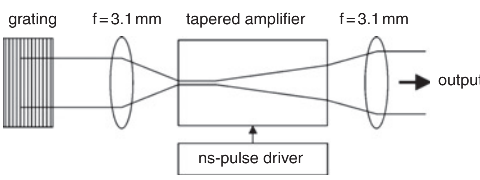

Fig. 1 *Experimental setup of the external cavity tapered laser*

Experimental results: Initially the laser system was characterised in CW operation. At a drive current of 3 A the laser outputs 1.89 W of power with a spectral width of below 0.004 nm. Light-current characteristics for CW operation are shown in Fig. 2 and a typical spectrum at 3 A drive current is shown in the inset in the Figure.

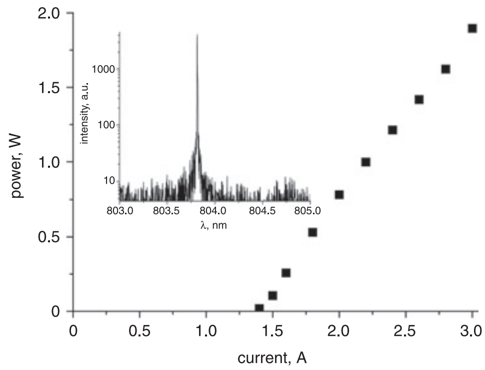

Fig. 2 *Light-current characteristics for external cavity tapered laser in CW operation at 20°C*

Inset shows spectrum of laser at maximum output power

In pulsed operation the drive current was increased to a maximum of 23.7 A, and the measured light-current characteristics at a wavelength of 799.8 nm and a temperature of 20°C are shown in Fig. 3. The threshold and slope efficiency of the laser under pulsed conditions are very similar to the values in CW operation. The output power increases approximately linearly with a slope efficiency of 1.1 W/A up to a current of 12 A, and above 12 A the slope efficiency decreases to 0.8 W/A. The decrease in slope efficiency is believed to be caused by a degradation of the beam quality from the ridge waveguide section of the laser reducing the feedback efficiency.

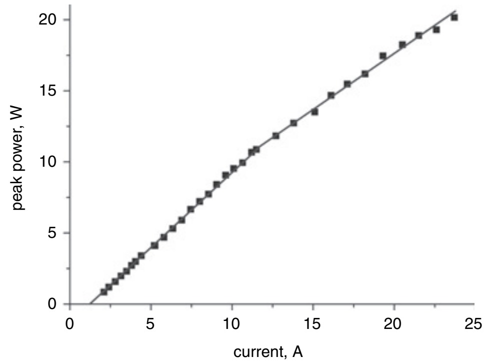

Fig. 3 *Light-current characteristics for external cavity tapered laser in pulsed operation at 20°C and with 60 ns pulse width at 500 Hz repetition rate*

The spectral behaviour of the laser was investigated using an optical spectrum analyser (ANDO AQ6317B). At a laser temperature of 20°C the laser wavelength could be tuned in the range 778–808 nm as shown in Fig. 4. Here 10 spectra at different wavelengths and the spectrum of a tapered laser with a high reflectivity coating on the back facet have been included for comparison. It is clearly seen that the spectral width is significantly narrowed using external cavity feedback. The spectral width of the pulsed freely running tapered laser without external feedback is approximately 3.2 nm (FWHM) and 10 nm including 95 % power. The spectral width of the external cavity laser at 20 W peak power is 0.16 nm (FWHM) or 0.18 nm including 95 % of the power and an example of the output spectrum is shown in Fig. 5. In the inset of Fig. 5, the different longitudinal modes of the external cavity laser can be clearly distinguished. The broadening of the spectral width compared to CW operation is believed to be caused both by the chirp during the current pulse [7] and deterioration of the beam profile from the back facet of the laser. At 10 W peak power the spectral width is as narrow as 0.04 nm (FWHM).

The beam quality of tapered lasers under pulsed operation has been investigated recently [8]. Here it was found that 808 nm tapered lasers with a similar structure to the one reported on here emitted up to 9 W peak power in a nearly diffraction-limited beam. No attempts have been made to investigate the beam quality of our laser system.

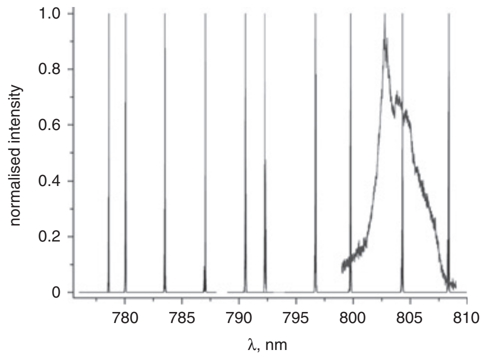

Fig. 4 *Wavelength tuning for pulsed external cavity tapered laser at 20°C*
Spectrum of a normal coated tapered laser is included for comparison

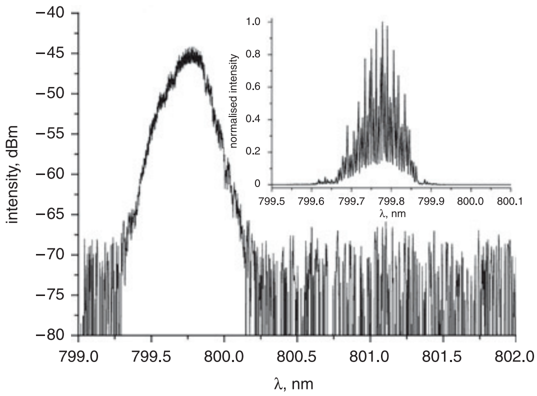

Fig. 5 *Spectrum of external cavity tapered laser in pulsed operation with 20 W peak power at 20°C and with 60 ns pulse width at 500 Hz repetition rate*
Inset shows spectrum on a linear scale

Conclusion: For the first time a current pulsed high power external cavity tapered laser system tunable in the range 778–808 nm has been demonstrated. The external cavity tapered laser system emits more than 20 W of peak power in a narrow spectral range of 0.16 nm. This makes this light source interesting for spectroscopic applications and for the pumping of frequency conversion experiments.

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