GaAs-based distributed feedback laser at 780 nm for ^{87}Rb cold atom quantum technology

Ying Ding[1], *Gary Ternent*[1], *Anwer Saeed*[1], *Craig J. Hamilton*[1,2], *Nils Hempler*[2], *Graeme P. A. Malcolm*[2], *Gareth T. Maker*[2], *Marc Sorel*[1], *Douglas J. Paul*[1]

1. *School of Engineering, University of Glasgow, Oakfield Avenue, Glasgow, G12 8LT, UK*
2. *M Squared Lasers Ltd, 1 Kelvin Campus, West of Scotland Science Park, Maryhill Road, Glasgow, G20 0SP, UK*

The UK Quantum Technology Hub in Sensors and Metrology [1] has the aim of developing integrated, small and practical cold atom systems for a range of sensor and timing applications which includes rotation, magnetism, gravity and atomic clocks. The approach is similar to that pioneered by the chip scale atomic clock [2] where atoms held in microfabricated vacuum chambers have atomic transitions excited and probed by diodes lasers [3] and photodetectors. That system used coherent population trapping for the clock transitions whilst we are aiming to first produce lasers for cooling and trapping ions inside vacuum chambers before microwave pulses or controlled lasers are used to create superposition states, recombine them and measure the interference from the final state populations. For cooling ^{87}Rb atoms, 780.24 nm lasers with linewidths below ~5 MHz are required whilst the lasers for controlling and measuring superposition states typically external cavity lasers have been used to achieve linewidths from 20 kHz [3] down to a few Hz [4]. Most single mode diode lasers aimed at laser cooling have used DBR gratings with regrowth [5] but this is challenging when using AlGaAs materials due to oxidation.

Here we present single mode 780.24 nm DFB AlGaAs/GaAs lasers with output powers up to 50 mW and sidemode suppression ratios above 46 dB (Fig. 1(a)) using sidewall etched gratings (Fig. 1(b)) and no regrowth. The lasers demonstrate clear DFB performance allowing tuning through the required 780.24 nm without any mode hopping. Initial tests for short ridge devices indicate linewidths of ~10 MHz and initial lifetime tests have exceeded 200 hours. We will discuss methods being pursued to increasing the power and reducing the linewidth through longer ridges [5], coupled cavities and by integrating SOAs. Control of the population of electrons in hyperfine split states requires two laser outputs spaced by ~3.617 GHz. Fig 1(c) demonstrates the principle of two DFB lasers operated on the same waveguide where the present line spacing has been increased to 30 GHz to allow a clear measurement by our OSA. Careful control of the gratings and the current enable 3. 617 GHz to be achieved. We will present results comparing two coupled DFB lasers (Fig. 1(c)), direct modulation, external AOMs and integrated AOM approaches and discuss which are best suited for integrated cold atom systems.

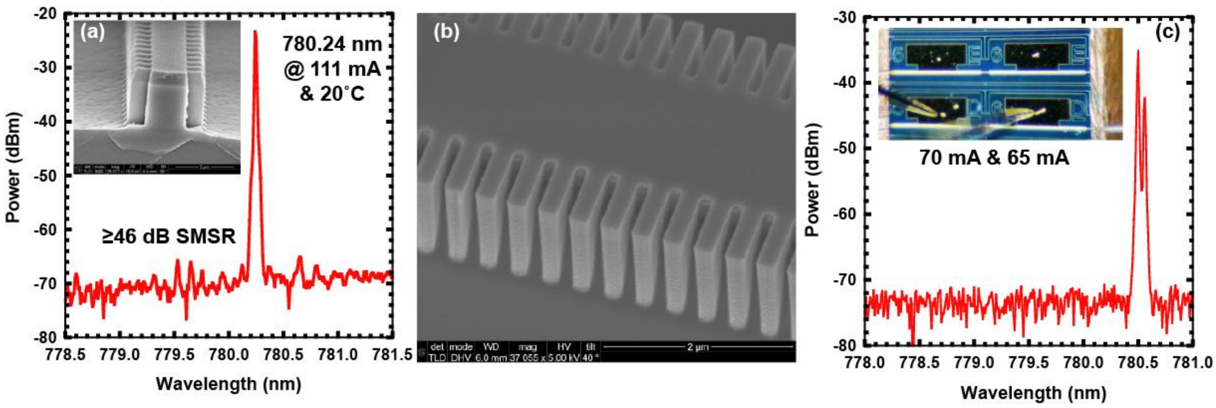

Fig. 1 (a) 780.24 nm single mode side walled DFB laser with ≥46 dB sidemode suppression ratio at 111 mA and 20 ˚C. The insert shows an SEM image of the end facet of one device. (b) A SEM image of the third order sidewall grating. (c) The dual mode lasing spectrum of two DFB lasers on the same waveguide. The inset shows a microscope picture of the DFB laser with two 1-mm sections. The spacing is 30 GHz between the lines achieved with 70 and 65 mA to allow measurement on the present OSA which demonstrates the principle to achieve two closely spaced wavelengths for cold atom applications.

References

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