Passively Mode-Locked semiconductor laser for Coherent Population Trapping in ^{87}Rb

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Recent growing interest in miniature atomic frequency references and precision magnetometers has motivated investigations of coherent population trapping (CPT) and its use in such applications [1]. System designs based on picosecond mode-locked lasers have been previously reported for generating the CPT effect, using Ti:Sapphire lasers passively mode-locked at a submultiple of the hyperfine splitting ^{87}Rb levels [2], or laser diodes modulated electrically [3] or with an external electro-optic modulator [4] at the ^{87}Rb splitting frequency. In this work we investigate a novel approach for achieving CPT in ^{87}Rb vapour cells. We use a 795nm semiconductor laser passively mode-locked [5] at the ^{87}Rb standard frequency (6.834GHz). This approach eliminates the need for any RF driving circuit, allowing a more compact, integrable and easy to drive implementation of CPT in ^{87}Rb. For the purpose we have fabricated 5.678mm long lasers with 3µm wide and 1.2µm deep ridge waveguides, with a 150µm long saturable absorber (SA) at one facet. The laser material used is a 793nm GaAs/$Al_xGa_{1-x}As$ single quantum well (QW) graded-index separate confinement heterostructure (GRINSCH), with an epitaxial design similar to the one reported in [6].

For these devices we measured a threshold current of ~90mA and a maximum output power of ~63mW (I_g=220mA, V_{SA}=0V). Mode-locking operation occurs for gain currents higher than 160-170mA and SA voltages between 0 and -2V, where an RF peak at around 6.85GHz is obtained. The gain current is kept not higher than 230mA and the SA reverse voltage not higher than -2V, to avoid damages to the laser facets or to the SA, respectively. In this range the emission wavelength remains around 795nm at 20^{o}C (an optical spectrum is in Fig.1(a)) with temperature tenability of ~0.3nm/^{o}C. The highest RF peak occurs at around I_g=210mA and V_{SA}=-0.5V, with a -3dB width of ~95kHz (shown in Fig.1(b)). For these biasing conditions also the narrowest pulses (~0.71ps) are obtained with two-photon interferometric autocorrelation measurements [7]. The autocorrelation trace is reported in Fig.1(c) and in the inset the full width half maximum value is measured. The peak power associated to the narrowest pulses is about 10.3W (correspondent to an average power of 50mW).

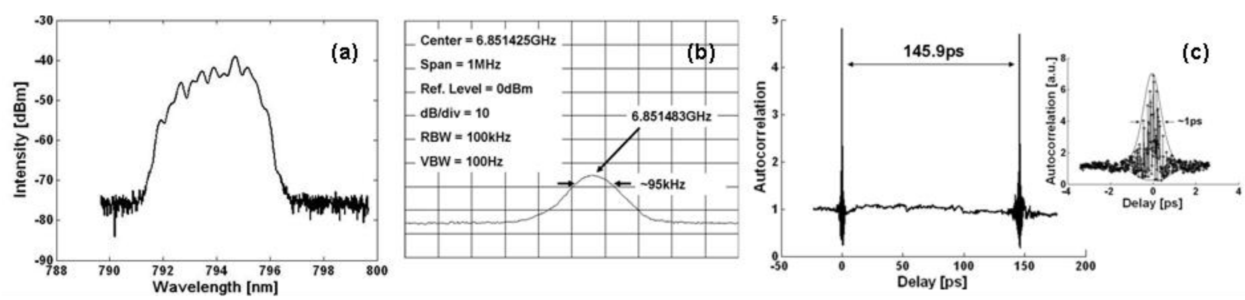

Fig. 1 (a) Optical spectrum for I_g=210mA and V_{SA}=-0.5V and (b) correspondent RF spectrum is in the inset. (c) Interferometric autocorrelation trace recorded for I_g=210mA and V_{SA}=-0.5V and a higher resolution trace in the inset.

The RF frequency increases with the gain current and decreases with the SA reverse bias, remaining between 6.84 and 6.852GHz in the biasing range considered. For I_g=210mA, a temperature tuning rate of ~333kHz/^{o}C has also been measured. These results show that our 795nm passively mode-locked lasers are promising candidates as compact and easy to drive sources to be used in experiments on CPT in ^{87}Rb.

References

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