Dual Wavelength Laser Designed for Locking to Cs-133 Atomic Transitions

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In this paper, a phase locked dual wavelength laser (PLDWL) with a sampled Moiré sidewall grating operating at 894 nm is proposed. The beat frequency between the lasing lines is designed to be 9.19 GHz, equal to the difference frequency between two hyperfine energy levels in atoms of caesium-133. The PLDWL therefore has applications in miniature atomic clocks and room temperature magnetometers. Constructions of monolithic dual wavelength lasers with a phase locked beat frequency have been demonstrated [1-2]. However, because the wavelength spacing corresponding to the 9.19 GHz frequency separation is only 0.0245 nm, the difference in the periods of the dual gratings would be 0.0037 nm (assuming n=3.3412) which is beyond the limits of the technology used previously [1-2]. However, by utilizing a sampled Moiré grating, dual wavelength operation with a 9.19 GHz frequency separation can be achieved by setting the sampling periods of a laterally coupled dual grating laser.

Fig. 1 shows a schematic of the PLDWL. The 80-µm-long electro-absorption modulator (EAM) is present to enhance phase locking of the two lasing modes [1]. The sidewall gratings on either side of the ridge have the same seed grating period Λ of 120 nm but different sampling periods, i.e, P_1 =1165 nm and P_2 =1163.5 nm. The initial phase difference between P_1 and P_2 is set to π. The laser is designed to operate at the -1^{st} order sub-reflection.

Fig. 2(a) shows the equivalent refractive index modulation distribution along the cavity. It has a rapidly varying component (blue line) with a slowly varying envelope (red line) [3]. When the slowly changing envelope passes through the zero point, an equivalent π phase shift (π-PS) occurs. The rapidly varying period and the slowly varying envelope can be adjusted by changing P_1 and P_2 [3]. For a cavity length L=3.5 mm and with P_1=1165 nm and P_2 =1163.5 nm, the two π-PSs are located at 1/3L and 2/3L. Fig. 2 (b) shows the transmission spectrum calculated using the transfer matrix method. Two transmission peaks are present in the stopband around 894 nm which are where dual-wavelength lasing occurs. Fig. 2(c) shows the calculated optical spectrum; the two lasing wavelengths are 894.007 nm and 894.0315 nm. The coupling coefficient of the uniform seed grating is 19/cm. Feedback of the signal from Coherent Population Trapping (CPT) of ^{133}Cs atoms to the PLDWL is used to tune the mode spacing to be exactly at the hyperfine splitting 9.192631770 GHz by changing PLDWL's grating current for coarse tuning and/or the EAM section's reverse voltage for fine tuning.

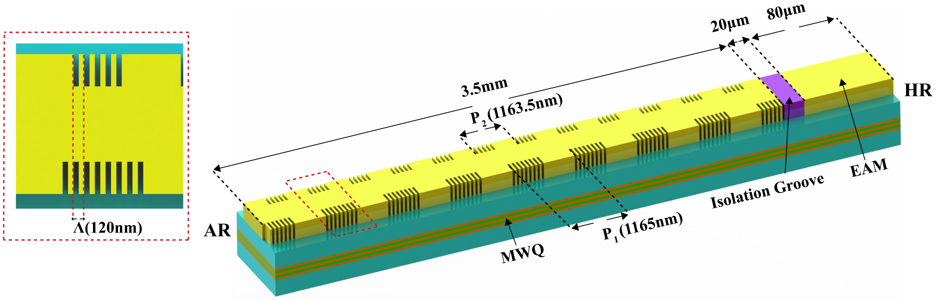

Fig. 1. The structure of proposed laser, the inserted figure is the enlarged view of the seed grating (red dotted line).

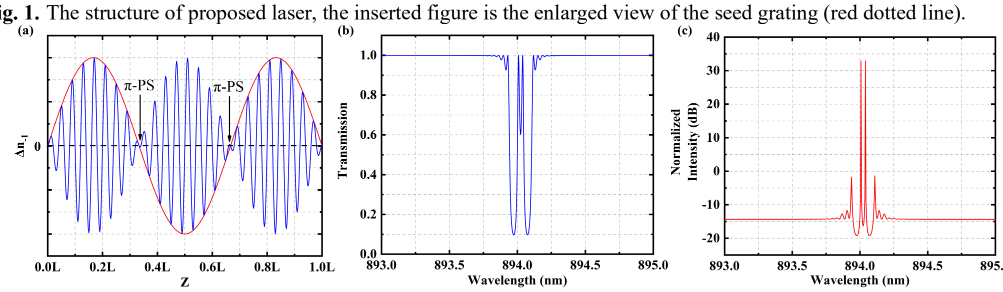

Fig. 2. (a) The equivalent refractive index modulation distribution along the cavity, (b) transmission spectrum, (c) calculated optical spectrum.

References

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