Photodigm

APPLICATION NOTE: PHOTODIGM *SPECTROSCOPY SERIES* LASERS

Rubidium Absorption Spectroscopy

Introduction

Ultra-high resolution laser spectroscopy of the rubidium atom at 780 nm has numerous applications in sensing, metrology, and aerospace. Despite these opportunities, commercial product development has been hindered by unstable sources of supply of precision, reliable semiconductor lasers at this wavelength. Photodigm has introduced a 780 nm high-power distributed Bragg reflector (DBR) laser diode in its *Spectroscopy Series* that has the characteristics necessary to meet this growing commercial need. These devices are fabricated using Photodigm's proprietary technology encompassing grating design methodology, single-growth epitaxy, and ridge waveguide process with holographic gratings. Typical output power of these DBR lasers is 60 mW. With a side-mode suppression ratio exceeding 45 dB over the specified range, they are ideal for spectroscopic applications.

This robust process ensures high yield at the target wavelength and high reliability with long lifetime. As a result both atomic spectroscopists and instrument manufacturers will be able to confidently move forward with their programs.

Experimental Set-up

The optical part of the experimental set-up consist of a beam splitter BS, two photodetectors PD1 and PD2, a 100 mm long glass cell filled with natural rubidium, and Photodigm's 780 nm high-power DBR laser diode (see Fig. 1). An oscilloscope measures the ratio between the two signals.

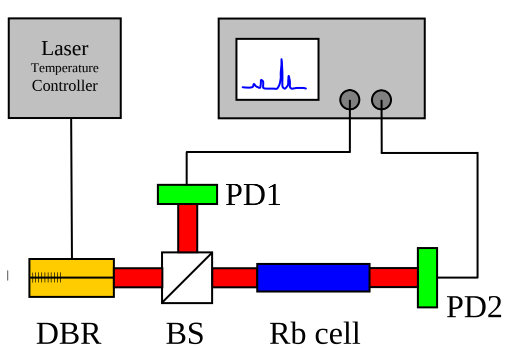

Fig. 1: Schematic of experimental set-up.

A constant current of 78 mA and a small 10 kHz saw-tooth modulation of a few mA simultaneously drove the DBR laser diode. The heat sink temperature was tuned until the absorption lines were centered on the scope. Thermal and current tuning are 0.6 Å/°C and 0.026 Å/mA, i.e. 30 GHz/°C and 1.3 GHz/mA, respectively.

Results

Natural rubidium consists of mainly two isotopes: ^{85}Rb (72.2%) and ^{87}Rb (27.8%). Focusing on the D2 transition, both isotopes absorb around 780.024 nm but their corresponding hyperfine splitting frequencies are different. The ground state of either isotope splits into two hyperfine levels. The exited state hyperfine splitting is masked by the ~500 MHz Doppler broadening so that individual levels are indistinguishable by simple spectroscopy techniques. Thus, the expected transitions have ground state hyperfine detuning of 6.834 GHz and 3.035 GHz for the isotopes ^{87}Rb and ^{85}Rb, respectively. Figure 2 presents the absorption spectrum of natural rubidium monitored with the mentioned set-up. The four absorption peaks, two resulting from each isotope, are clearly visible and distinguished.

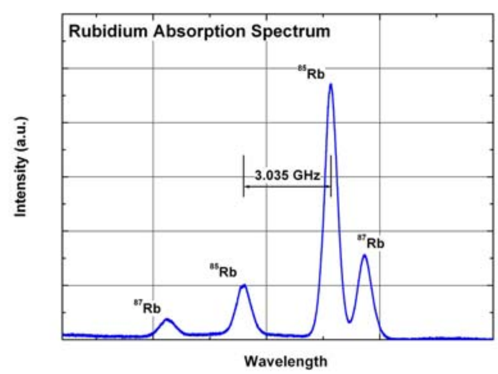

Fig. 2: Absorption spectrum of ^{85}Rb and ^{87}Rb recorded using Photodigm 780 nm DBR laser tuned over a 7 mA range.

The linewidth of the used DBR laser diode is below 10 MHz and compared to the Doppler broadening of the transitions almost two orders of magnitude smaller.

Laser Lifetime

A cell of six DBR laser diodes has been monitored over time, when running in constant power mode. The rated output power was 60 mW and the selected temperature was fixed at 25°C, 45°C and 65°C (see Fig. 3).

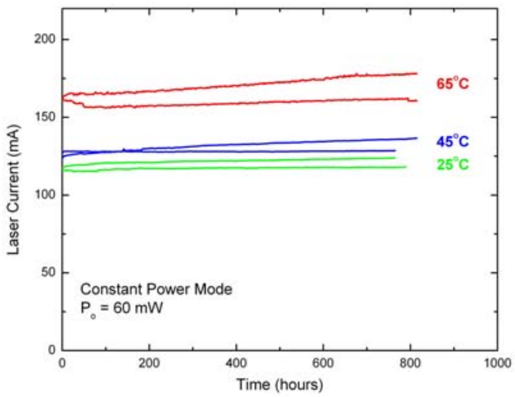

Fig. 3: Injection current against operation hours (ongoing test, as of March 3, 2008).

Initial lifetime data were estimated assuming a current limit of 1.5 × the initial current value. Table I presents mean-time-to-fail MTTF values for three different temperatures.

Temp (ºC)	MTTF (1.5 x start current [hrs])
25	41,560
45	20,380
65	11,260

Table I: Projected device lifetime based on operation hours.

Further 780 nm DBR Laser Applications

The PD780DBR-1-LD has many uses within the bio-medical, sensing, metrology, and aerospace markets. Atom cooling and trapping applications benefit greatly from the high power and frequency stability found in Photodigm's proprietary DBR structure. Data storage such as optical ROM, holographic storage, and disc mastering are all uses for 780nm DBR laser.
One of the highest growth areas for this single-frequency, high power DBR lasers are in navigation and spectroscopy.

Photodigm's lasers can simplify instrumentation design by reducing or eliminating the need for amplification or frequency stabilization components. This can result in dramatic cost savings for OEMs. Contact Photodigm for a laser solution, tailored to your application.

About Photodigm

Founded in 2000, Photodigm produces semiconductor diode lasers for the precision instruments and defense markets using its proprietary distributed Bragg reflector technology. By focusing on high power, single frequency diode lasers in the industrially significant 780 nm to 1100 nm spectral range, Photodigm is bringing unique capability to its customers, who have not had access to a stable supply of product.

Photodigm lasers are offered at 780, 920, 976, 1064, and 1083 nm wavelengths as standard products free space optical and fiber pigtailed packages. The Spectroscopy Series offers the target wavelength +/- 0.5 nm, and the Power Series at wavelength +/- 3 nm.

Custom wavelengths and applications support for spectroscopy, non-linear optics, and fiber amplifier seeding are available from Photodigm.

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