# Tunable DFB Laser Array for Multi-gas Detection

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## Abstract

We designed a tunable Distributed FeedBack (DFB) laser array with a large tuning range based on Reconstruction-Equivalent-Chirp (REC) technique near the wavelength of 1650nm for the first time. We experimentally demonstrated that the laser with wavelength ranging from 1650.4nm to 1657.6nm can be continuously adjusted by selecting the corresponding channel and changing the bias current to detect methane, water vapor, carbon dioxide and carbon monoxide. Furthermore, the idea of this DFB laser for gas detection without Thermo Electric Cooler (TEC) is put forward at last.

Keywords-DFB laser; REC; Multi-gas Detection; TEC

## Introduction

The optical spectroscopy method based on infrared absorption spectrum technology is widely used because of its high discrimination and selectivity. Beer-Lambert law is the theoretical basis of gas detection, which can be expressed as

$$I_t(v) = I_o(v)exp(-a(v)CL) = I_o(v)exp(-Sj(v)\ PCL).$$

The schematic diagram of a typical gas detection system is shown in Fig. 1 (b), the line- absorption intensity of methane is shown in Fig. 1 (a) by querying the database of HITRAN. And H2O (1652.01nm), CO2 (1650.66nm/1651.12nm) and CO (1656.55nm) also have absorption peaks of certain intensity near this wavelength.

We can realize π phase shift equivalently in the middle position of the grating corresponding to each channel. We utilize the wavelength of +1 order channel as the working channel to improve the single-mode characteristics of the laser, as shown in Fig. 1 (c). By designing the structure of the sampling grating, the DFB laser with good characteristics can be made economically.

$$\lambda_{Bragg} = 2n_{eff}\Lambda_{+1}$$

$$1/\Lambda_{+1}=1/\Lambda_0+1/P$$

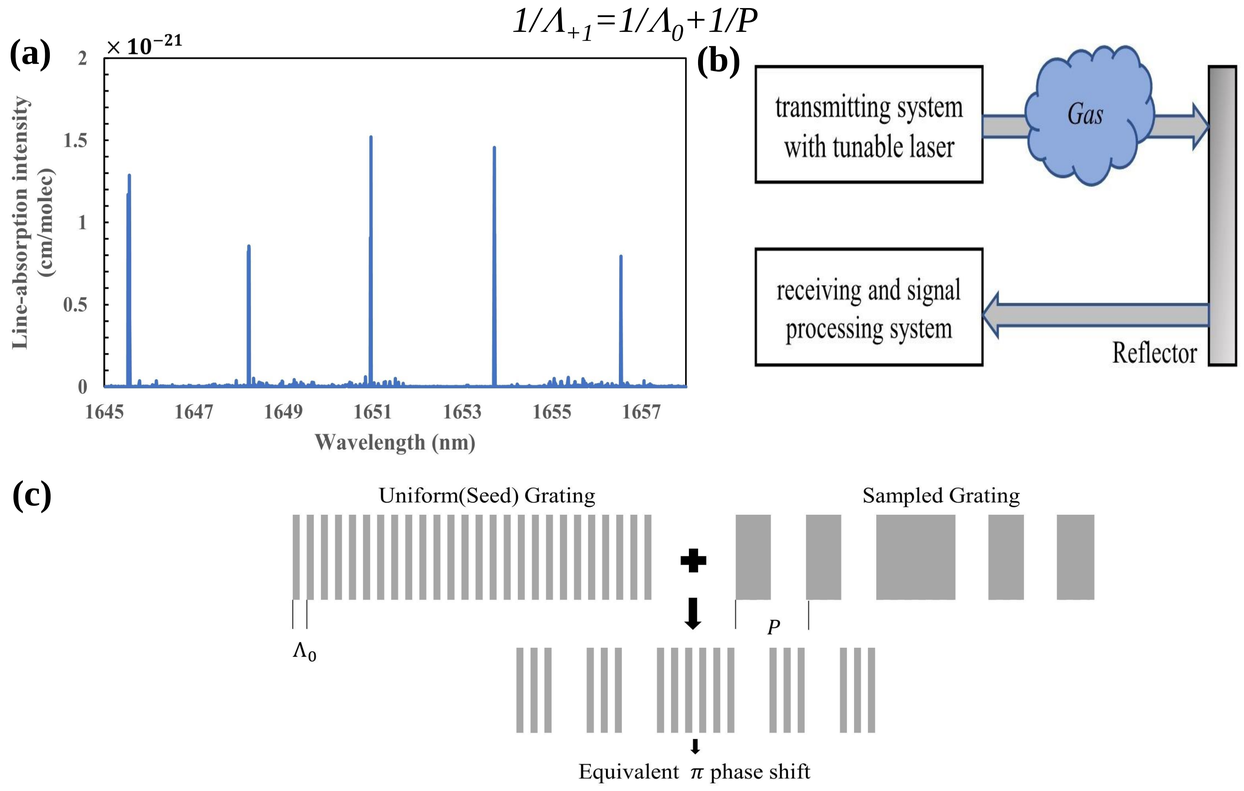


Fig. 1 (a) Line-absorption intensity of methane in the wavelength range from 1645 to 1658nm (b) The typical configuration of gas detection system (c) Schematic diagram of sampling grating with REC

## Measurement of the Laser

The DFB laser has three laser diodes on a waveguide, as shown in microscopic image Fig. 2.


Fig. 2 Microscopic image of the chip

## Summary of Experiment Results

The following is a partial spectrum of the laser, the significant characteristic-SMSR of the laser and the summary of the current tuning characteristics.

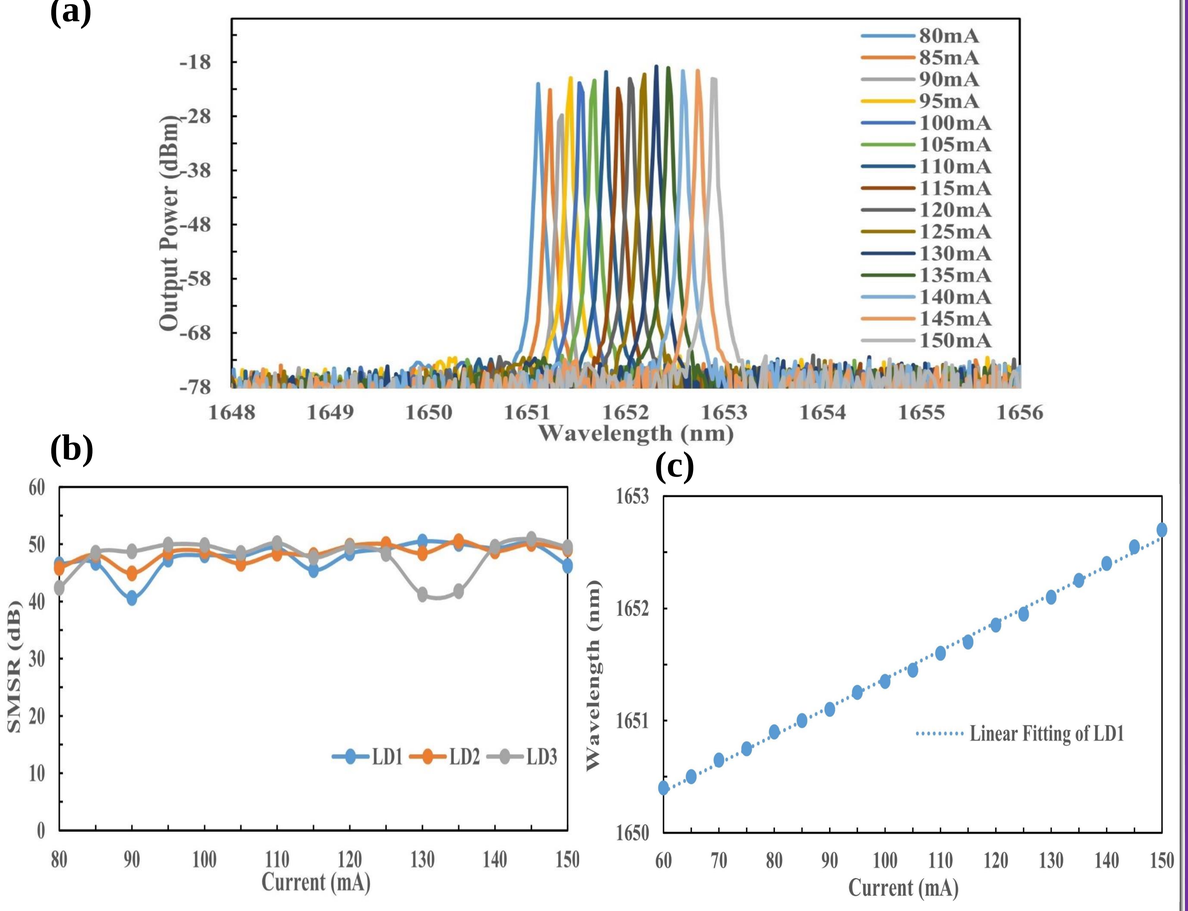


Fig. 3. (a) The Spectrum of LD1 (b) SMSRs of the Laser (c) The current-wavelength tuning diagram of LD1

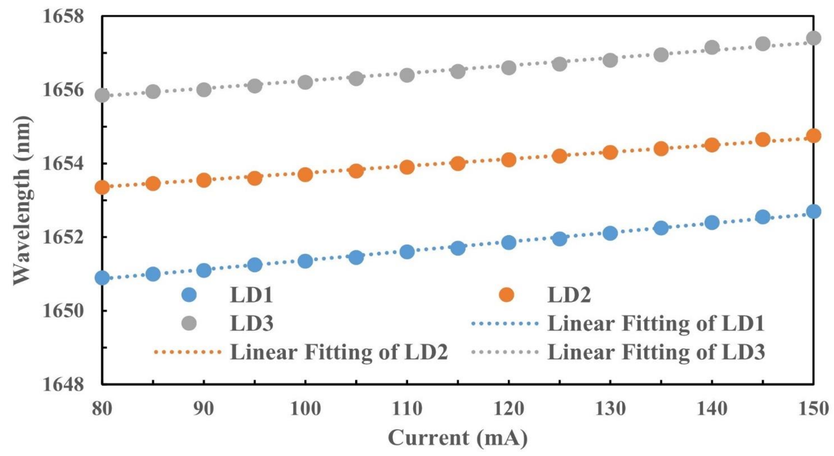


Fig. 4. The current-wavelength tuning of lasers

## Conclusion

The laser can emit the wavelength ranging from 1650.4nm to 1657.6nm, covering the gas absorption peaks of CH4, H2O, CO2 and CO. Therefore, the output wavelength needed can be achieved by selecting the corresponding working channel and utilizing the current tunning property to adjust. The main advantage of the laser is that a single detector system with a laser is enough to detect various gases .

The above experiments and applications should be carried out under the condition of temperature control using TEC. Because of its large tuning range, the laser can also be used without TEC, which greatly reduces the volume of the laser and the packaging cost of the laser. The tunning characteristics of temperature and current are determined by the semiconductor material, and the theoretical coefficient is 0.1nm/℃. At the temperature of 30℃, the laser can also be used to detect above three kinds of gases. If other conditions are properly set, the wavelength range can be achieved from 1654.4nm to 1661.6nm at the temperature of 60℃, covering the absorption peaks of CH4 and CO. Similarly, the same calculation can be made at lower temperatures.

## References

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