WAVELENGTH-TUNABLE LASER SOURCE BY A SLD SYSTEM WITH AN OPTICAL FEEDBACK MECHANISM

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Abstract --- *We construct an experimental system using a SLD device as the light source to observe the difference of the output light characteristics when an optical feedback mechanism is exerted, and we achieve a wavelength-tunable laser source by a SLD system with the feedback mechanism incorporating a dispersive prism.*

Keywords: *superluminescent diode (SLD), optical feedback, wavelength-tunable laser*

1. INTRODUCTION

Broadband light sources such as light-emitting diodes (LEDs) and superluminescent diodes (SLDs) have been widely used for the optical measurement [1], and especially the SLD broadband source has been playing an important role in the optical coherence tomography system [2, 3]. The unique property of SLD is the combination of laser-diode-like output power and brightness with broad LED-like optical spectrum. Furthermore, the extremely high optical gain in SLD active region may result in very high optical power sensitivity to external optical feedback [4]. Thus, once stimulated emission due to optical feedback occurs, the strength of the output light should be increased to achieve optical amplification, and the evident variations of the optical polarization and spectrum shape should also be observed. Besides, tunable optical feedback in spectral domain can also be used to choose the output wavelength of the laser source.

In this study, we construct an experimental system using a SLD device as the light source to observe the difference of the output light characteristics when an optical feedback mechanism is exerted, and we successfully achieve a continuously wavelength-tunable laser source when we incorporate a dispersive prism into the feedback branch.

2. THE INFLUENCE OF AN OPTICAL FEEDBACK ON A SLD LIGHT SOURCE SYSTEM

We use a SLD broadband light-emitting device (HAMAMATSU 8414-04) [5] as the experimental system source, and we measure the basic optical characteristics such as the optical power, polarization, and spectrum, for the case of free running broadband light without optical feedback (Figure 1), and for another case with optical feedback (Figure 2).

The measured optical power of the lasing light is about 7 times that of the SLD system without optical feedback. The enormous increase of the output optical power indicates that the light-emitting process has changed from spontaneous emission to stimulated emission. Besides, we launch the output light into a linear polarizer and measure the optical power variations of the transmitted light by rotating the linear polarizer to explore the polarization state of the output light. The spontaneous emission light of the SLD system without optical feedback is observed to be elliptically polarized with TE/TM polarization ratio = 3:1 [Figure 1(b)], and the stimulated emission light of the SLD system with optical feedback is nearly linearly polarized light [Figure 2 (b)]. Furthermore, we measure the spectrum of the output light directly by a spectrometer. The output spectrum of the SLD system without optical feedback is rather broad with a spectral width of 21.75 nm [Figure 1(c)], while the output spectrum of the SLD system with optical feedback shows a highly sharp peak with a spectral width of 2.03 nm [Figure 2(c)]. Therefore, when the lasing occurs, the output light is both linearly polarized and monochromatic. That is to say we can obtain a high-power, linearly polarized, and narrowband laser light source by constructing a SLD system with optical feedback.

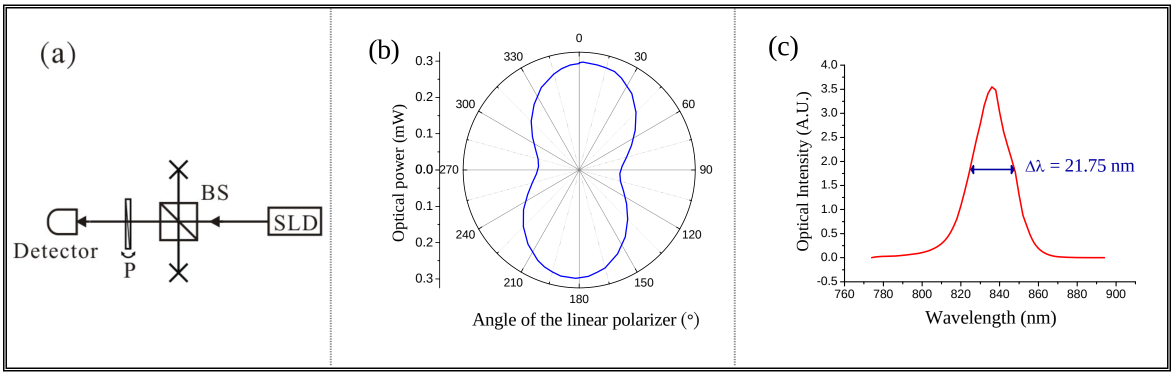

Figure 1. Experimental setup and measured results for the case without optical feedback. (a) Schematic of experimental setup. BS, beam splitter. P, polarizer. (b) The optical power versus the angle of the linear polarizer in polar coordinates. (c) The output spectrum and spectral width.

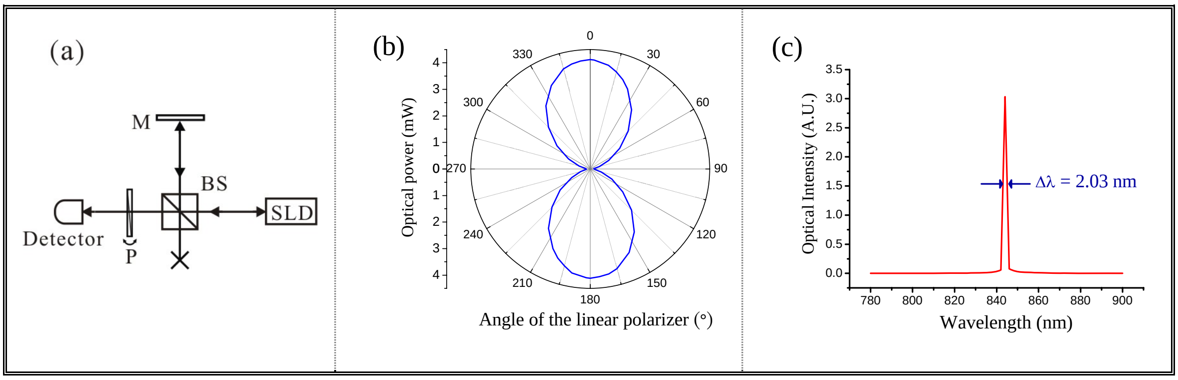

Figure 2. Experimental setup and measured results for the case with optical feedback. (a) Schematic of experimental setup. BS, beam splitter. P, polarizer. M, reflection mirror. (b) The optical power versus the angle of the linear polarizer in polar coordinates. (c) The output spectrum and spectral width.

3. WAVELENGTH-TUNABLE LASER SOURCE

In this section, we intend to develop a wavelength-tunable laser source by a SLD device. At first, following the preceding experimental setup, we construct a SLD system subjected to an optical feedback mechanism, and then insert a prism between the beam splitter and the reflection mirror to select the wavelength of lasing by tuning the angle of the reflection mirror slightly, as described schematically in Figure 3. Finally, we monitor the variation of the laser output spectrum by a spectrometer and tune to the desired lasing wavelength.

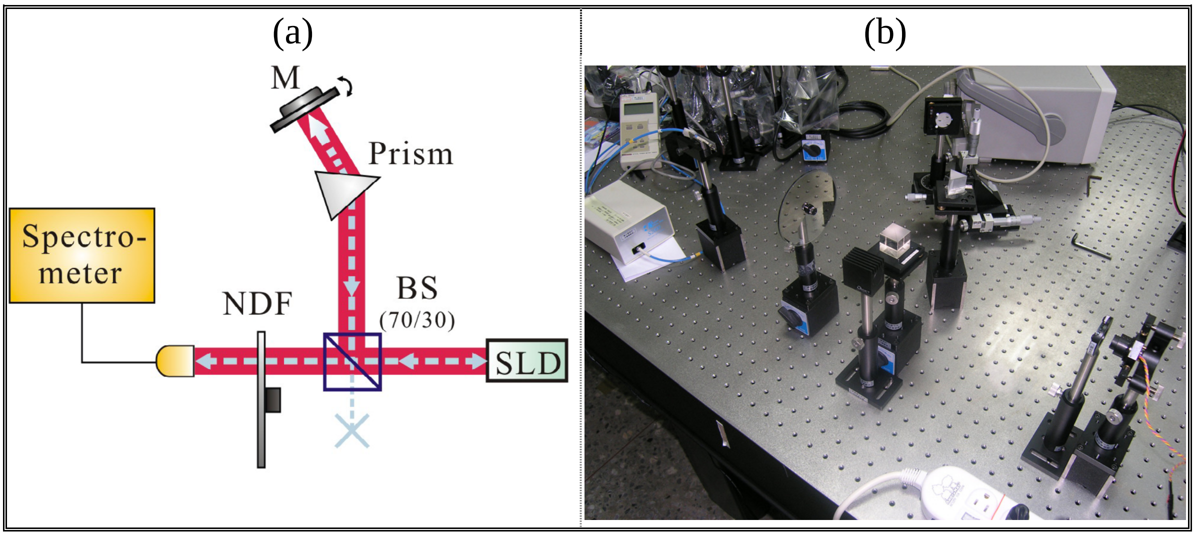

Figure 3. Experimental setup of the wavelength-tunable laser source. BS (70/30), beam splitter (70% reflection and 30% transmission). Prism, dispersive prism. NDF, neutral density filter. M, reflection mirror. (a) Schematic of setup. (b) Photograph of setup.

As we can see from the measured spectra (Figure 4), the center wavelength tunable range of the laser output is about from 830 nm to 850 nm with a magnitude of 20 nm. The laser output at center wavelength λ_0 = 844.38 nm has the maximum optical intensity which is measured directly by a power meter to be about 3 mW. When the lasing center wavelength is shifted away from 844.38 nm, the output optical intensity will be reduced down gradually due to the gain decrease of the SLD at other wavelengths. The measured spectral widths of the laser output spectra are nearly 2 nm, and the output spectra are observed to be rather stable during the measurement. In a word, we achieve a stable and continuously wavelength-tunable laser source by a SLD system with the feedback mechanism incorporating a dispersive prism.

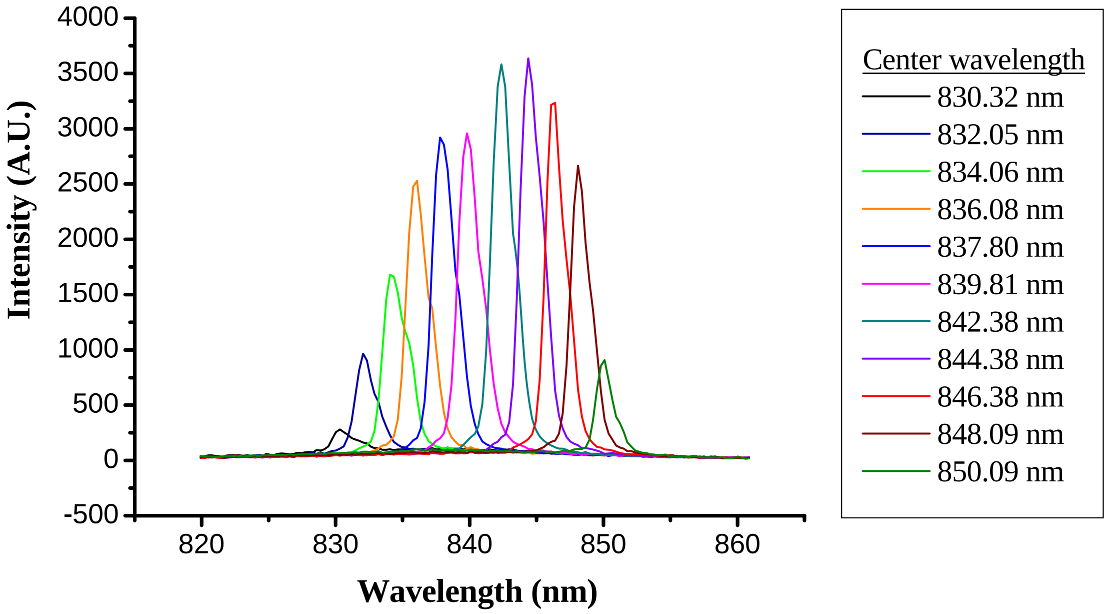

Figure 4. Spectra of the wavelength-tunable laser source. The center wavelength tunable range of laser output is about from 830 nm to 850 nm.

4. CONCLUSION

In summary, we have presented the experimental setups and measured results that elucidate the nature of the optics and gain effects of a SLD broadband light source subjected to an optical feedback. An optical feedback could lead to very large increase of the optical gain and output power, indicating that stimulated emission process has also been caused. When the lasing occurs, a strong output light that is both linearly polarized and monochromatic can be obtained. Furthermore, by incorporating a dispersive prism into the feedback branch to select the desired wavelength, a stable and continuously wavelength-tunable laser source is achieved, and the tunable range is about from 830 nm to 850 nm with a magnitude of 20 nm.

5. REFERENCES

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