Monolithically Integrated Narrow Linewidth Semiconductor Laser With a Narrow Band Reflector

Hongji Wang, Yuechun Shi, Yitao Wu, Yuxin Ma, Ziming Hong, Haoyuan Wu and Xiangfei Chen*， *Corresponding author: shiyc@nju.edu.cn*

Abstract

We proposed a monolithically integrated narrow linewidth semiconductor laser composing of an active section and a passive narrow band reflector (NBR) based on waveguide Bragg gratings. The π phase shifted Bragg grating is used in the active section to obtain single longitudinal mode output. The NBR is consist of a taper waveguide, π phase shifted anti-symmetric Bragg grating (π-PS-ASBG) and uniform Bragg grating. Two sections are integrated on an identical InP wafer and share one continuous waveguide. Because of the hybrid mode resonance in the passive section, it has a relatively long effective length to narrow the linewidth of laser. When the laser's length is 800 μm and coupling coefficient of the π-PS-ASBG is 180 cm^{-1}, narrow linewidth about 16 kHz is obtained .

Principle

The schematic of the NLSL is shown in Fig. 1. It consists of the active section with π phase shifted Bragg grating (π-PS-BG) and the passive section. The waveguide of the active section is a single mode waveguide (SM-WG). The passive section consists of a taper waveguide, a dual mode waveguide with π phase shifted anti-symmetric Bragg grating (π-PS-ASBG) and uniform Bragg grating (UBG). In order to reduce the cost, all Bragg gratings are fabricated by using the sampled grating, which only requires one step holographic exposure combined with micrometer-level photolithography.

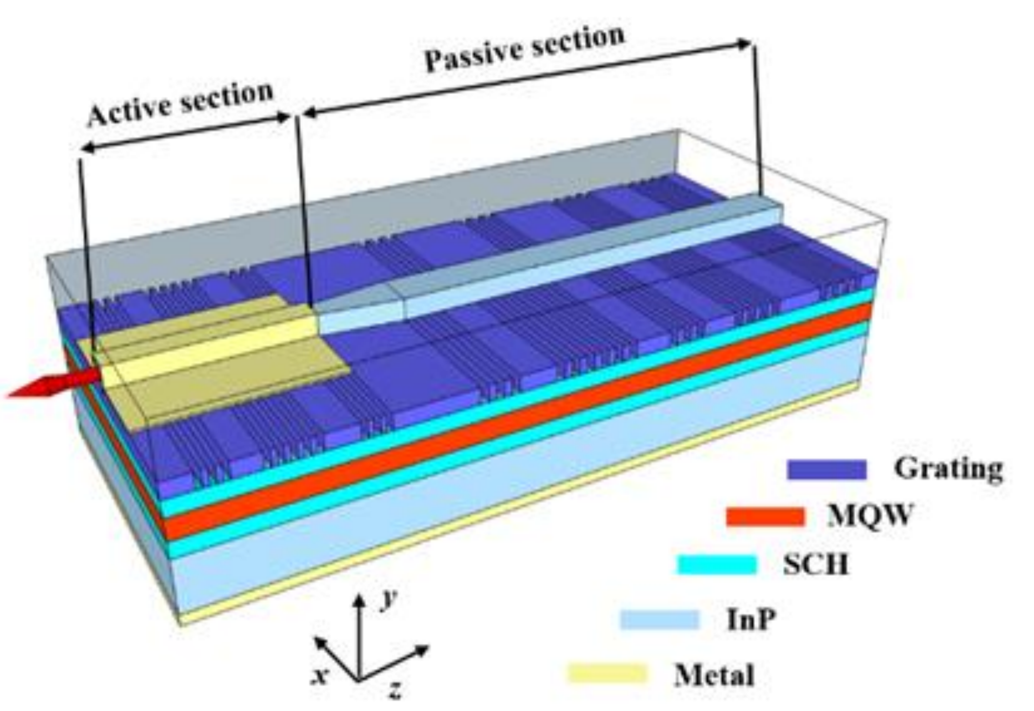

Fig. 1. Schematic of the proposed NLSL.

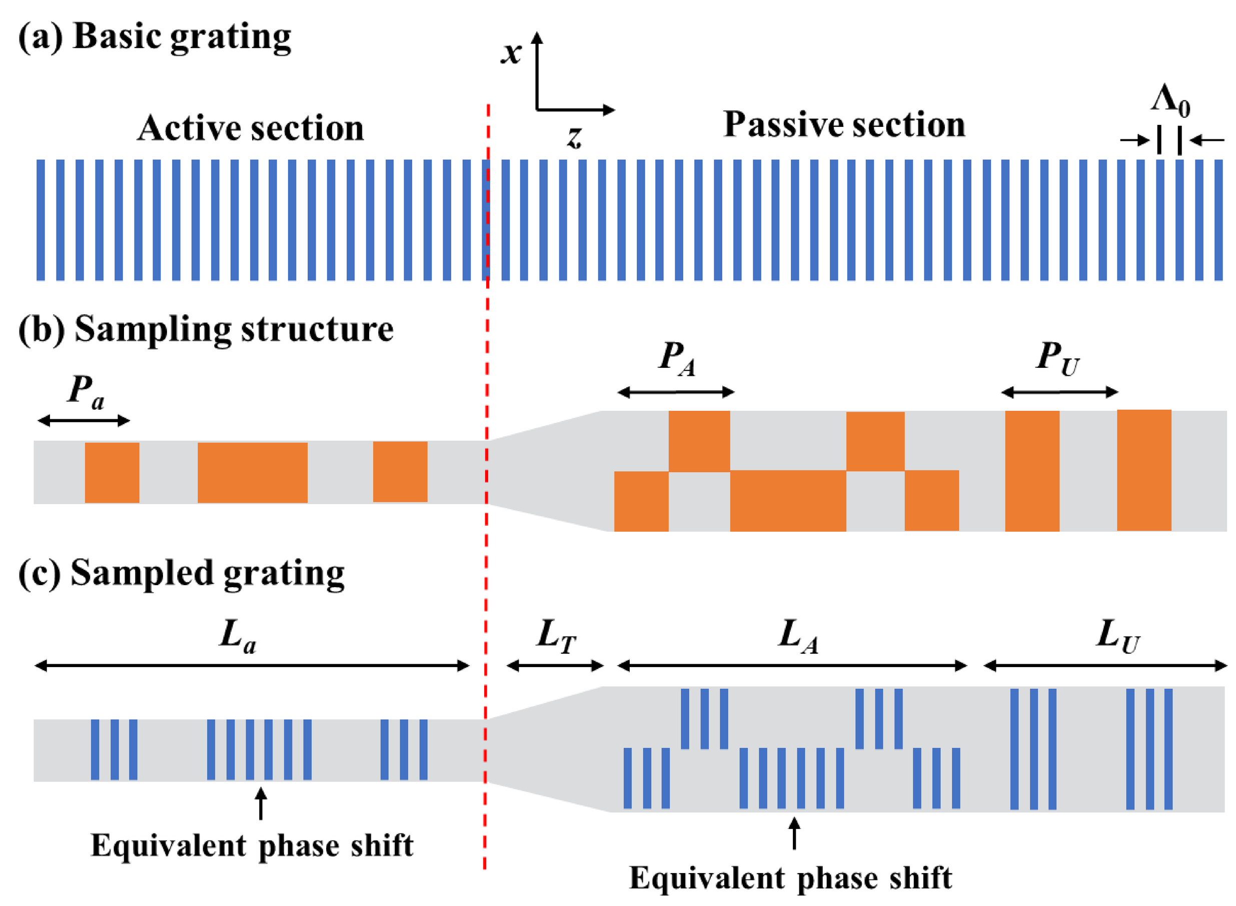

Fig. 2. Schematic of (a) uniform basic grating, (b) sampling structure and (c) sampled grating.

Simulation

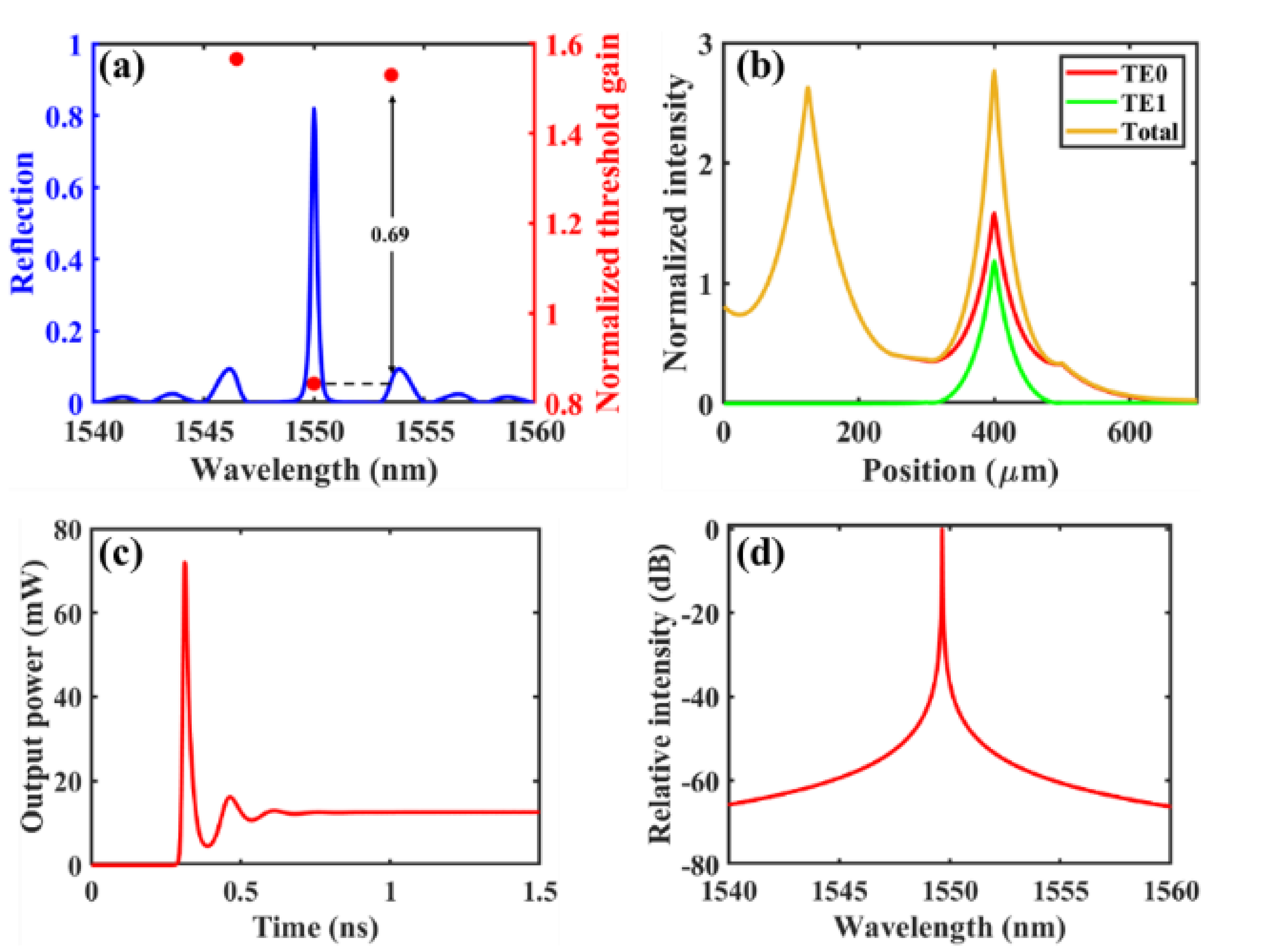

Fig. 3. Calculated (a) reflection spectrum of the NBR and threshold gains of the NLSL, (b) normalized photon density along the NLSL, (c) transient responses of the NLSL and (d) output light spectrum of the NLSL.

Analysis of the Linewidth

From the model proposed by Takahashi, the spectral linewidth of a laser with Bragg grating reflector can be expressed as,

$$\Delta\nu = \left(\frac{L_a}{L_a + L_{eff}}\right)^2 \cdot \Delta\nu_0$$

where L_a is the length of active section, L_{eff} is the effective length of passive section and $\Delta\nu_0$ is linewidth of the laser without passive reflector. In our design, L_{eff} is related to the length of π-PS-ASBG (L_A) and the coupling coefficient of π-PS-ASBG (κ_{01}).

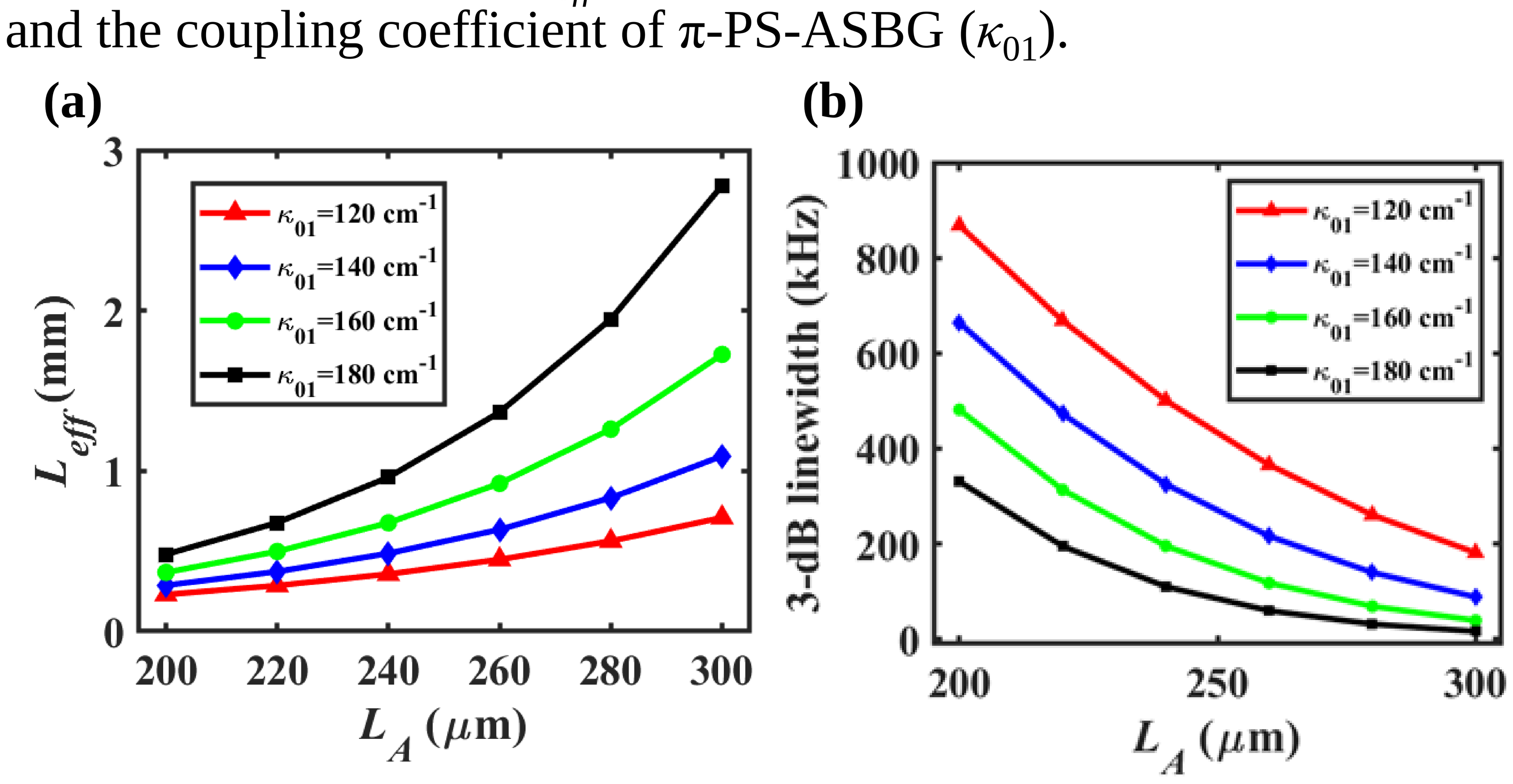

Fig. 4. Calculated (a) effective length of the passive section (L_{eff}) versus L_A with different κ_{01} and (b) 3-dB linewidth of the proposed NLSL versus L_A with different κ_{01}.

Conclusion

In conclusion, we proposed a monolithically integrated NLSL which uses the NBR structure as the passive section. The NLSL was theoretically studied and simulated. According to our calculation, the laser can emit 16.25 kHz linewidth light with 800 μm laser length. These results show that the proposed NLSL can be applied to the coherent optical communication system due to its narrow linewidth and high integration.