Topics

A Device Simulator of Semiconductor Lasers

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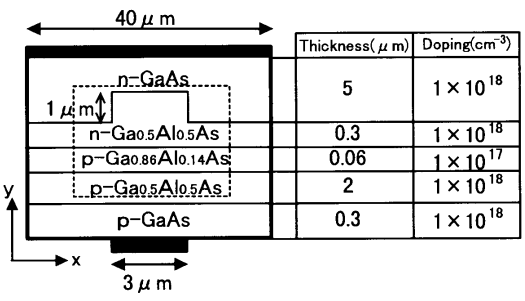
1. Introduction

A semiconductor device simulator is an indispensable tool for the design and development of semiconductor devices because of its advantage in evaluating characteristics of devices without trial manufacture. A conventional device simulator requires physical properties of semiconductor materials as input data for the characteristics evaluation, and the evaluation is in fact impossible for the devices using the materials for which a sufficient stock of experimental data is unavailable, such as semiconductor lasers using new materials. As a solution, a device simulator of semiconductor lasers to evaluate optical properties of the semiconductor from calculated main input data instead of experimental data stock has been developed.

2. Method

(1) For the calculation, the exact equation deduced from the semi-classical theory is used which describes the interaction between electron, hole and light quantum-theoretically and the behavior of the light as an electromagnetic field expressed by the classical theory. The spontaneous emission recombination rate and the optical gain coefficient by the stimulated emission which are the physical quantities determining the optical properties are obtained for each of the materials which constitute the semiconductor laser.

(2) Using the values obtained in (1), solve the equation that describes the electrical properties in combination with the equation that describes the optical properties. Considering that a typical semiconductor laser has a plane structure, two-dimensional calculation was carried out in the present study.



Thickness(μm)	Doping(cm^{-3})
5	1×10^{18}
0.3	1×10^{18}
0.06	1×10^{17}
2	1×10^{18}
0.3	1×10^{18}

Fig. 1 Structural parameters of a semiconductor laser.

3. Results

The calculation object was a semiconductor laser having a GaAs/Ga1-xAlxAs heterojunction (X: Al mole fraction) (**Fig. 1**). The current-optical output properties according to the exact equation proposed in this study are confirmed to be equivalent to those obtained from the experimental value of the optical gain coefficient (**Fig. 2**). Fig. 3 shows the near field light intensity of the simulated laser, indicating that the light output is concentrated on the active layer of the laser.

4. Summary

A device simulator of semiconductor lasers in which the basic properties of the laser are calculated from the laser shape and impurity concentration has been developed. This simulator has made it possible to calculate the main input data that used to be dependent on the materials such as the optical gain coefficient.

Reference

1) Ohtoshi, T., et al., Solid-State Electronics, 30-6 (1987), 627

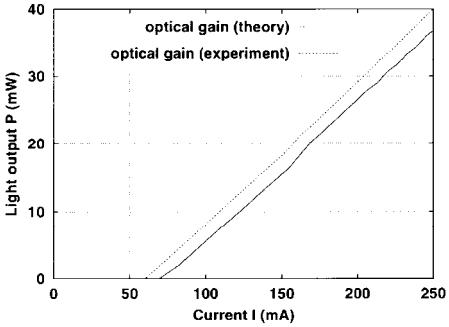


Fig. 2 Light-Current characteristics.

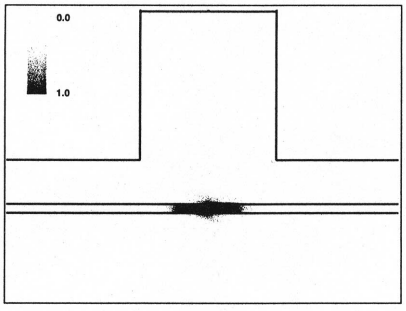


Fig. 3 Near field light intensity. The result of the region surrounded by broken line rectangle of Fig. 1.