行政院國家科學委員會補助專題研究計畫成果報告

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※ **新型光電材料、元件及雷射光源(II) – 總計畫** ※
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執行期間：**88 年 8 月 1 日 至 89 年 10 月 31 日**

計畫主持人：楊 志 忠

本成果報告包括以下應繳交之附件：

□ 赴國外出差或研習心得報告一份
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執行單位： 國 立 台 灣 大 學 光 電 所

中 華 民 國 九十 年 一 月 十 日

國科會專題研究結案報告

新型光電材料、元件及雷射光源(II) – 總計畫

Novel Optoelectronics Materials, Devices, and Laser Sources

計畫主持人： 楊志忠　　執行單位： 國立台灣大學光電所

共同主持人：張宏鈞、江衍偉、林浩雄

計畫編號： **NSC 89-2215-E-002-036**

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中文摘要：

本整合研究結合四位教授針對新型光電材料、元件及雷射光源之發展進行努力，他們已獲致相當多的成果，共發表 12 篇 SCI 文章。

Abstract:

This research combines the efforts of four faculty members for the development of novel optoelectronics materials, devices, and laser sources. They have accomplished quite many results and published 12 SCI journal publications.

BRANCH PROPOSAL I:
Novel Semiconductor, Fiber, and Nonlinear Optics Devices

We have implemented acoustically modulated fiber Bragg grating devices for Bragg reflection modulation, reflection wavelength switching, and Q-switched erbium-doped fiber laser. On semiconductor devices, we have observed self-modulation of mode-locking mechanism in an external-cavity semiconductor laser. Regarding nonlinear-optics devices, we have proposed the use of a grating structure for phase-compensation in a PPLN crystal of incomplete period. Also, with collaborators we have implemented optical parametric oscillators with KTP crystals, pumped with Ti:sapphire lasers.

Related Journal Publication List:

1. Chih-Wei Hsu and C. C. Yang, "Using a Grating Structure for Phase Compensation in Achieving Efficient Round-trip Optical Parametric Process in PPLN with an Incomplete QPM Period," Optics Letters, Vol. 24, pp. 540-542, 1999.
2. D. W. Huang, W. F. Liu, C. W, Wu and C. C. Yang, "Reflectivity-tunable Fiber Bragg Grating Reflectors," IEEE Photonics Technology Letters, Vol. 12, pp. 176-178, 2000.
3. Chih-Chang Chen, Yean-Woei Kiang and C. C. Yang, "Colliding-pulse Mode-locked Semiconductor Laser with a Multimode-interference Waveguide Amplifier," Optics Communications, Vol. 177, pp. 363-368, 2000.
4. Yih-Jun Wong, Hong-Hsieng Chen, Choong-Wen Lai, Yean-Woei Kiang, and C. C. Yang, "Self-modulation in an External-cavity Semiconductor Laser," Optics Communications, Vol. 180, pp. 317-321, 2000.
5. Wen-Fung Liu, I-Ming Liu, Lung-Wei Chung, Ding-Wei Huang, and C. C. Yang, "Acoustics-Induced Reflection Wavelength Switching in a Fiber Bragg Grating," Optics Letters, Vol. 25, no. 18, pp. 1319-1321, 2000.
6. D. W. Huang, W. F. Liu, and C. C. Yang, "Q-Switched Fiber Laser with an Acoustically Modulated Fiber Attenuator," IEEE Photonics Technology Letters, Vol. 12, no.9, pp. 1153-1155, 2000.
7. Cheng-Yen Chen, Kung-Jeng Ma, Yen-Shen Lin, Chung-Yen Chao, Steffen Gurtler, Chee-Wee Liu, Chih-Wei Hsu, and C. C. Yang, "Formation of Silicon Surface Gratings with High Pulse-Energy UV Laser," J. Applied Physics, December,

2000.
8. J. Q. Yao, X. Ding, J. Y. Qiao, C. C. Yang, I. J. Hsu, and C. W. Hsu, "Pump-Tuning Optical Parametric Oscillation and Sum-Frequency Mixing with KTP Pumped by a Ti:sapphire Laser," accepted for publication in Optics Communication.
9. Yan-Ju Chiang, Likarn Wang, Wen-Fung Liu, Horng-Shyang Chen, Chih-Wei Hsu, and C. C. Yang, "Temperature-Insensitive Strain Measurement Using Two Fiber Bragg Gratings in a Power Detection Scheme," submitted to IEEE Photonics Technology Letters.

BRANCH PROPOSAL II:

Research on Pro-pagation Characteristics of Semiconduc-tor Optical Waveguides (VI)

When analyzing waveguides with sharp corners, the field singularities at these corners always cause difficulties in obtaining a rapidly converging full-vectorial solution. In this research we have successfully established an efficient and highly accurate three-dimensional full-vectorial finite element numerical model by introducing inhomogeneous elements to properly handle the boundary conditions at the interface between different dielectrics and at the corners of the dielectric structure. The formulation has been based on the transverse fields. More accurate modal analysis has been achieved for rectangular dielectric waveguides and ridge waveguides. We study to what extent the interface affects the numerical result of the modal fields and propagation characteristics by adjusting the size of the added inhomogeneous element and the number of nodes. On the other hand, we continue to study various properties of different antiresonant reflecting optical waveguides (ARROWs) using our recently proposed modified finite element method. The ARROW is a relatively new type of slab waveguide with low loss and good polarization and mode selectivity. All ARROW modes are leaky waves, and our method can accurately determine their complex propagation constants. We have investigated the leaky and propagation characteristics of coupled structures formed with the ARROWs and with the ARROW-B guides.

Related Journal Publications:

1. D. U. Li and H. C. Chang, "An efficient full-vectorial finite-element modal analysis of dielectric waveguides incorporating inhomogeneous elements across dielectric discontinuities," IEEE J. Quantum Electron., vol. 36, no. 11, pp. 1251-1261, 2000.

BRANCH PROPOSAL III:

Numerical Study on Nonlinear Phenomena in Semiconductor Optical Amplifiers (II)

In this branch project, we have accomplished the studies on the following topics:

(1) Numerical analysis of an all-semiconductor-optical-amplifier Sagnac interferometer device

Nonlinear optical loop mirrors (NOLM's) are useful for high speed signal processing and communications. Recently, we have implemented a monolithic all-semiconductor-optical-amplifier (SOA) nonlinear loop device, showing efficient power-dependent switching. The configuration of this device is the same as an NOLM, including an SOA loop and a multimode-interference waveguide amplifier for closing the loop. In this study, we numerically simulate the device in the case of continuous-wave (cw) signal operation. Relevant parameters are varied to evaluate their influences on the device performance.

(2) Numerical analysis of a colliding-pulse mode-locked semiconductor laser with a multimode-interference waveguide amplifier

Colliding-pulse mode-locking (CPM) has

been applied to semiconductor lasers, leading to fsec pulses. Basically, a CPM laser includes a saturable absorber where the counter-propagating pulses collide. In collision, the two pulses enhance the pulse compression effect of each other through power dependent absorption. Therefore, a saturable absorber is required in a conventional CPM laser for generating stable pulses. In this study, however, we demonstrate numerically a novel configuration for CPM semiconductor laser without using a saturable absorber. A multimode-interference (MMI) semiconductor optical amplifier (SOA) is used as the gain medium and the mode locker. Efficient pulse compression and stabilization of the two counter-propagating pulses are achieved based on the nonlinear coupling effect, assisted with pulse collision, in the MMI SOA.

Related Journal Publications:

1. Ding-An Wang, Chih-Chiarng Chen, Yean-Woei Kiang, Jiun-Haw Lee, and C. C. Yang, "Numerical Study on a Compact All-Semiconductor-Optical-Amplifier Sagnac Interferometer Device," Optical and Quantum Electronics, Vol. 32, pp. 585-608, 2000.
2. Chih-Chiarng Chen, Yean-Woei Kiang and C. C. Yang, "Colliding-pulse Mode-locked Semiconductor Laser with a Multimode-interference Waveguide Amplifier," Optics Communications, Vol. 177, pp. 363-368, 2000.

BRANCH PROPOSAL IV:
III-V Compounds Optoelectronics Materials and Devices

In this study, the GSMBE growth of low nitrogen content InAsN alloys, bulk-layers as well as quantum wells are investigated. The InAsN alloys were grown by using gas source molecular beam epitaxy (GSMBE) with RF plasma nitrogen source. For the highly strained InAsN/InGaAsP and InAsN/InGaAs multiple quantum wells (MQW's), a bowing effect was clearly identified by using PL measurements. The largest nitrogen composition obtained in this study is 5.9 %, and the 10K PL peak wavelength of this sample is as long as ~2.6 μm (480 meV). The PL results also reveal quality degradation due to nitrogen incorporation. The poor as grown sample with high nitrogen composition can be improved by using annealing technology. Finally, a 4-period $InAs_{0.97}N_{0.03}$-$In_{0.53}Ga_{0.47}As$-InP MQW lasers was fabricated successfully. The annealed sample lases at 200K under pulse-mode operation with a threshold current density of 1.5 KA/cm^2. The wavelength is as long as 2.37 μm. To our knowledge, this is the first report for InAsN laser.

The InAsN bulk-layers were grown on (100) InP substrates by using plasma-assisted gas source molecular beam epitaxy. The layers are 2-μm-thick and all have been relaxed. The band gap and electron effective mass were determined by using IR absorption and plasma frequency measurements. Surprisingly, contrary to the results of InAsN/InGaAs MQW, the fundamental absorption edge of bulk InAsN shifts toward high energies as nitrogen increases. After the Burstein-Moss effect due to high residual carrier concentrations in these bulk-layer being deducted from the fundamental absorption edge, bowing effect on these bulk InAsN is recovered.

Related Journal Publications:

J. S. Wang, and H. H. Lin, "Growth and post-growth rapid thermal annealing of InAsN/InGaAs single quantum well on InP grown by gas source molecular beam epitaxy", *J. Vac. Sci. Technol. B, Vol 17(5)*, pp. 1997-2000, (1999).

J. S. Wang, H. H. Lin, L. W. Sung, and G. R. Chen, "Growth of InAsN/ InGaAsP multiple quantum well on InP by gas source molecular beam epitaxy, " *J. Vac. Sci. Technol. B,* in press.