

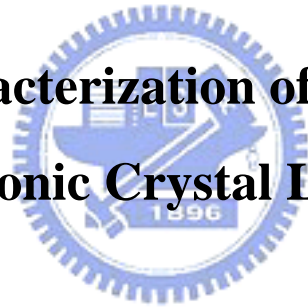
國立交通大學

光電工程研究所

碩 士 論 文

二維光子晶體雷射特性分析與設計

**Design and Characterization of Two-Dimensional
Photonic Crystal Lasers**



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摘要

我們於本文中展示了二維光子晶體的基本設計以及特性分析。首先，我們利用三維平面波展開法以及有限元素時域差分法來計算光能隙以及光子晶體微共振腔的缺陷模態及其頻譜，藉此，我們得以在結構設計上達成優化的目的。除此之外，本文中亦簡單的介紹了對稱與非對稱結構二維光子晶體雷射的製程技術。

為了量測並分析二維光子晶體的各种基本特性，我們架設了一套長波長共焦顯微光譜系統。利用此系統，我們觀察並分析了光子晶體微共振腔中的共振模態以及雷射激發模態，這其中包括了基本的雷射激發頻譜，光激發光輸出曲線，可調波長雷射行為，以及雷射模態的偏極化現象。

最後，我們亦架設了一套熱電半導體定溫系統，利用這套系統，我們得以探討二維光子晶體雷射的各种熱特性。在雷射波長熱調變的探討中，我們得到了與模擬結果相符合的實驗結果。此外我們還分析了此元件的臨界激發能量對於激發條件以及基板溫度的相關性。最後，我們計算了該元件的熱阻，並與目前的面射型垂直共振腔雷射做一比較。

Design and Characterization of Two-Dimensional Photonic Crystal Lasers

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In this thesis, we show the basic design and characteristics of two-dimensional photonic crystal lasers. At first, a series of simulations are performed by using three-dimensional plane-wave-expansion (PWE) method and finite-difference time-domain (FDTD) method in order to calculate the band diagrams and defect modes of the photonic crystal micro-cavities. According to these simulations, we can optimize the structure of the devices. The fabrication of the membrane and the asymmetric structure are also introduced.

We setup a micro-photo-luminescence (PL) system in order to characterize the two-dimensional photonic crystal lasers. The basic characteristics of the micro-cavities are investigated including resonance modes and lasing modes. The basic lasing properties are investigated such as lasing spectra, L-L curves, tuning properties and mode polarization.

We setup a thermo-electro cooler (TEC) system in order to characterize the thermal properties of two-dimensional photonic crystal lasers under different conditions. The lasing properties under different substrate temperatures are investigated both in experiment and theory. We also investigate the threshold dependence on different substrate temperatures and pump conditions. At last, we calculate the thermal resistance of two-dimensional photonic crystal lasers and compare it with that of general VCSELs for our future work.

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