

國立交通大學

光電工程研究所

碩士論文

具增強耳語廊模態之光子晶體共振腔拓樸優化  
及光耦合類分子之研究



**Topological Optimization and Photonic Molecule by  
Photonic Crystal Microcavity with Enhanced  
Whispering-Gallery Mode**

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## 摘要

本論文可分為兩大部分，在第一部分中，基於拓樸原理我們先模擬了微碟型(Microdisk)與微齒輪型(Microgear)共振腔中耳語廊模態(Whispering-Gallery Mode)的Q值最佳化過程，接著我們進一步設計出微花型(Microflower)共振腔，並討論這三者共振腔邊界對於Q值的影響。由於微碟型共振腔在優化會有體積上的限制，故我們在這部分也提出一具有耳語廊模態之光子晶體修正共振腔，我們以相同的討論結果作基礎，將Q值最佳化的對象換成在小體積時也能有良好Q值表現的光子晶體，成為花型拓樸光子晶體共振腔(Photonic Crystal Micro-Flower CD<sub>2</sub> Microcavity, PC MFCD<sub>2</sub>)，接著藉由製程方法實現該設計，並討論其量測結果。

在第二部分，我們會介紹另一種會應用在微碟型共振腔上的設計，也就是光子分子。而針對光子分子的概念應用在光子晶體上時，我們也提出一個全新的結構：基於光子晶體共振腔的雙層光子分子(Double Layer Photonic Molecules, DLPM)。同樣的我們會先介紹光子晶體共振腔光子分子在模擬上的結果，包括了光子分子模態以及其可調變的模態特性。接下來的章節中，我們主要會著重在製程方法的研究。利用設計的砷化鎵雙層磊晶結構，我們改變了樣本的設計，包括周期數與樣本旁蝕刻窗的大小，調變乾式與濕式蝕刻的時間，還有光子晶體洞本身的直徑，以完成雙層光子分子的製程結構。

# Topological Optimization and Photonic Molecule by Photonic Crystal Microcavity with Enhanced Whispering-Gallery Mode

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## Abstract

This thesis can be divided into two parts. In the first part, based on topology rule, we will investigate microdisk and microgear with whispering-gallery (WG) mode with azimuthal number six and optimize their quality ( $Q$ ) factors. And we will also investigate microflower topology by further modifying the edge of the grating in microgear. From these simulation results, we analyze and discuss the influence of cavity boundary on  $Q$  factors of WG modes. Since there is scale size limitation due to diffraction limitation in microdisk, we also propose a novel design of photonic crystal circular-shaped ( $CD_2$ ) microcavity with well-sustained WG mode. We will apply the same optimization method on this microcavity named photonic crystal microflower  $CD_2$  (MFCD<sub>2</sub>) microcavity. And then this design is realized by a series fabrication processes and the measurement results will be analyzed and discussed.

In part two, we will introduce the photonic molecules composed by microdisk and photonic crystal microcavity. We also propose a brand new photonic molecule (PM) design composed by two identical photonic crystal  $CD_2$  microcavity membranes in vertical direction named double-layer PM (DLPM). We will investigate and discuss the basic tunable PM states modal properties by 3D FDTD simulations, including  $Q$  factor and wavelength. And then we will develop the related fabrication process based on designed GaAs epitaxial structure. This will include the process by changing patterns design, periods of the pattern, the windows and holes size, and dry / wet etching time.

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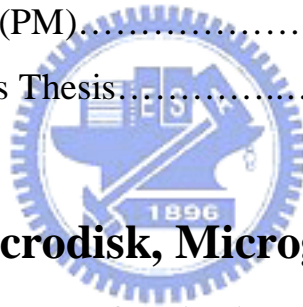


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