111 10IPT 692000　課程綱要表

課程名稱	（中文）半導體光電量子特性				
	（英文）Quantum Properties of Semiconductor Optoelectronics				
開課單位	電機系	授課教師	李依珊	課程代碼	IPT 6920
選課性質	□必修■選修	學分數	3	開課年級	碩博
先修科目或先備能力	固態物理、量子力學導論				
課程概述	本課程以微觀與介觀物理解釋半導體光電元件的量子特性。在充分習得了量子力學後，可用單粒子狀態計算出半導體能帶結構以及光物質作用。課程亦提供數個專題以啟發學生學以致用，包含低維結構基本理論與其應用、共振腔量子電動力學以及光偵測技術。 The course provides the essential knowledge to understand the quantum properties of semiconductor optoelectronics at microscopic and mesoscopic levels. After a comprehensive review of quantum mechanics, formulations of electronic band structures and light-matter interactions will be derived in the framework of single-particle state. Some special topics shall be selected for inspiring discussions at the end of this class, including the theory and practice of low-dimensional structures, cavity quantum electrodynamics and light detection.				
課程目標	學生習得低維奈米結構的物理，清楚在奈米結構中因量子效應可徹底改變半導體材料性質，進一步結合各式新穎奈米元件的操作概念，期能啟發學生之創新應用能力。 Students shall learn the theoretical and practical aspects of low-dimensional structures and gain the knowledge of quantized effects. After establishing the knowledge of novel optoelectronic devices, students can get inspired and are creative in thinking.				
教科書	自編教材				
參考書	1. Quantum Mechanics for Scientists and Engineers, D. A. B. Miller (2008) 2. Physics of Photonic Devices, S. L. Chuang (2009) 3. Quantum Theory of the Optical and Electronic Properties of Semiconductors, H. Haug and S. W. Koch (2009) 4. Quantum Optics, Y. Yamamoto (APPPHYS 387, Stanford University) 5. Mesoscopic Physics, Y. Yamamoto (APPPHYS 388, Stanford University) 6. Semiconductor quantum dots: physics, spectroscopy, and applications, Springer Y. Masumoto, T. Takagahara (2002)				
教學要點概述					
講義編選	☑自己編寫				
教學方法	☑講授 ☑學生上台報告　☑討論互動				
評量方式	期中與期末報告 Reading assignment and report				70%
	出席與小考 Attendance and Quiz				30%

課程綱要

單元主題	單元綱要
Basic Quantum Mechanics	Schrodinger Equation
	The square well
	The harmonic oscillator
	Perturbation theory
	Hydrogen atom and exciton in 2D and 3D
Electronic Band Structures	Bloch theorem and $k \cdot p$ method
	Kane’s model for band structure

	Luttinger-Kohn Hamiltonian –degenerate valence bands
	Effective mass theory
	Pikus-Bur Hamiltonian –strain effect
	Band structures of confined system
Light-Matter Interactions	Interband transition via Fermi's golden rule
	Einstein's A and B coefficients
	Absorption, gain, and spontaneous emission spectrum
	General absorption due to electron-hole pair & exciton effect
	Fully-quantized theory of absorption and emission
	Coherent regime: optical Stark shift & optical Bloch equations
Special Topic I: Low Dimensional System	Electronic, optical and magnetic properties of quantum dots
	Single quantum dot
Special Topic II: Semiconductor Cavity Quantum Electrodynamics	Jaynes-Cummings Hamiltonian
	Weak coupling regime and Purcell effect
	Strong coupling regime and Rabi splitting/oscillation
	Thresholdless photon laser
	Quantum dot in microcavity
Special Topic III: Light Detection	Photodetector
	Avalanche photodiodes
	Quantum dot infrared detector