全像波長元件及全像偏極化選擇元件在光交換網路與光通訊網路之應用 3/3
(Holographic WDM and Polarization-Selective Elements in Optical Switching and Communication Network Applications 3/3)

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主持人：黃遠東 教授
交通大學電子工程系系系
mail: huangyt@cc.nctu.edu.td

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1. 摘要

本三年計畫中，應用所設計開發之全像波長區分多工元件(WDM)於光通訊網路知交叉連接(cross-connect)方面，可提供波長選擇路徑功能(wavelength routing)。另外，應用設計開發之全像偏極化選擇元件，組成基本全像光交換元件，以設計各種多級光連線交換網路，可除去元件間之連接線，充分達到輕、薄、短小，系統易於安置的特性。

Abstract

Using our holographic polarization-selective elements to construct multistage interconnection networks, all interconnection lines between switches can be eliminated. Holographic wavelength-selective elements can provide wavelength routing functions in network cross-connect applications.

2. 計畫緣由與目的

本三年計畫，目的在設計及研製全像多波段波長多工/解多工(WDM/WDDM)元件與全像光偏極化選擇性(Polarization-Selective)元件，以為光交換與光通訊網路之應用。光通訊為目前訊號傳輸最重要的方式之一，而波長區分多工(WDM, Wavelengh-Division-Multiplexing）技術，可增加通訊頻道的容量與設計彈性;同時,WDM也可有效應用於通訊交換網路上。因此，世界各先進國家皆積極發展WDM技術。其中全像光學元件對光繞射(diffraction)具有色散(dispersion)特性，極適合高密度WDM系統。本研究群多年從事WDM全像基本元件研製方面的研究，且有相當成果，本計畫也將推展WDM全像元件至WDM Cross-Connect交換網系統路應用上。在光通訊網路上，目前有各種多級交換連線網路正積極發展中，各有其優缺點及適用範圍。前幾年本研究群發展了偏極性分光全像元件，以及與電光調制半波片(Electro-Optic Half-wave Plates)組成之基本交換元件單元(Switch)，並初步應用在Benes、Batcher's、Crossbar及Multisage各種不同多級交換連線網路上，並作系統的設計及性能分析。本三年之計畫，將擴展其系統性，將包含WDM、WDDM、Star Couplers、Cross-Connect與各種光交換網路之子系統，並評估組合各子系統以建立一完整系統其特性及應用性。使用全像光學元件在以上系統的應用，皆具有輕薄短小、容易製作、垂直同軸耦合、容易對準及低價格等優點。整個系統也將往減少元件與降低整體能量消耗方向設計。

3. 結果與討論

在光交換網路上，我們使用光偏極化選擇性基片傳輸型全像元件，發展了具有二組態（直行與交換連接）與三組態（直行、交

換與反轉連接）的可逆式 2x2 基本光交換元件；另一方面，也開發了與光偏極性無關之 2x2 光交換元件，如圖一所示。藉以上所發展之元件，設計多種輕薄結構之光連線交換網路，並作系統特性分析。圖二例所示，為Benes 8x8，圖三例所示為Cyclic crossbar 光連線交換網路。並設計了分光應用之Star Couplers。

在波長區分多工應用上，與光偏極性無關之高效率基片傳輸型全像元件已被設計及製作。為增加頻寬，可用反射式繞射，效率高於80%之頻寬可達 76 nm。我們已分別設計製作了工作於780, 1050, 1300, 1550 nm波長區分元件，並以疊層結構應用於多波段波長區分解多工系統，可大幅增加光通訊系統之傳輸容量。本研判群設計了各種不同結構之多工分光系統，圖四所示為本偏極化與波長區分多工例。

所發展的元件均具有實用性，陸續發表在學術期刊、國際會議，並獲得多項專利。詳細內容請參考以下所列之參考文獻。

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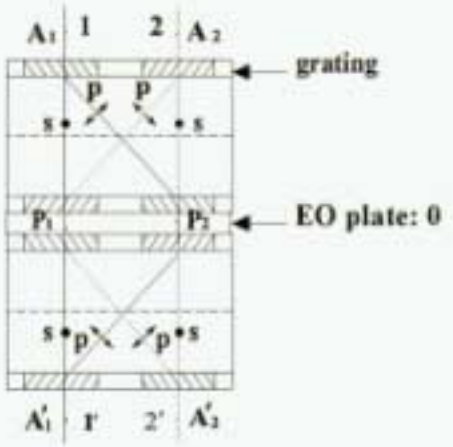


Fig. 1 Bidirectional polarization-independent switch.

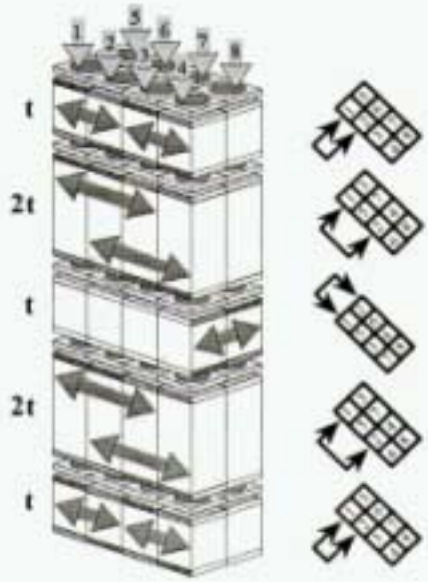


Fig. 2 Three-dimensional structure of 8×8 Benes interconnection network with holographic optical switches.

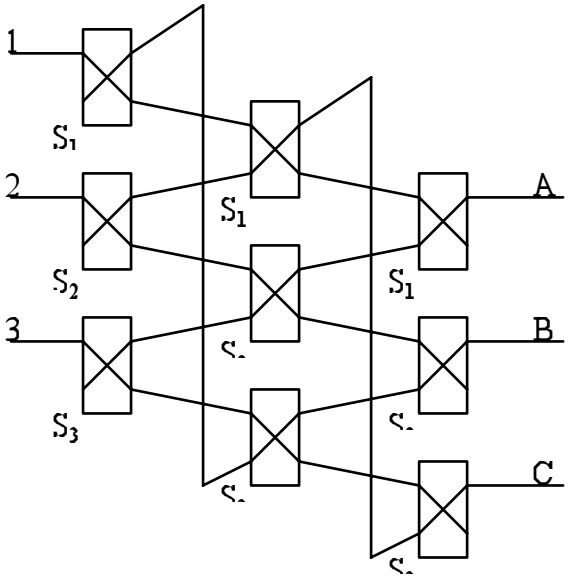


Fig.3 Cyclic crossbar network with switching elements.

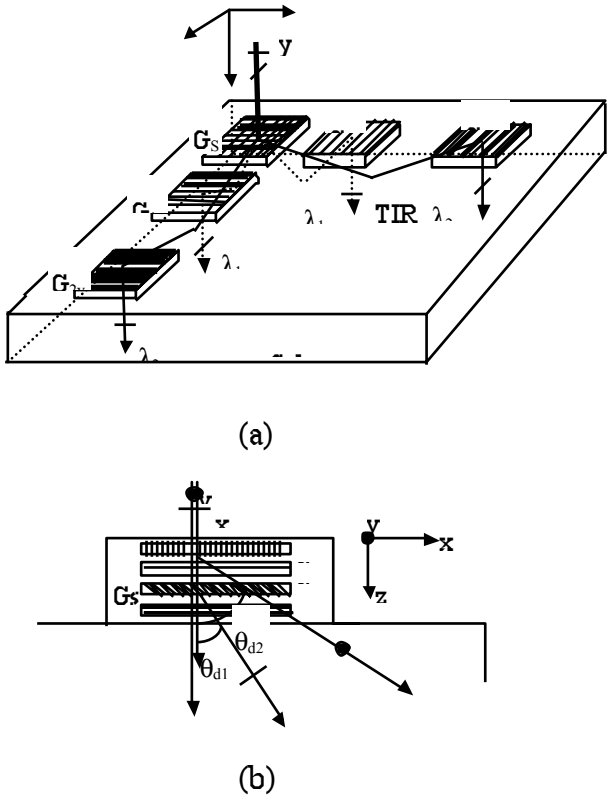
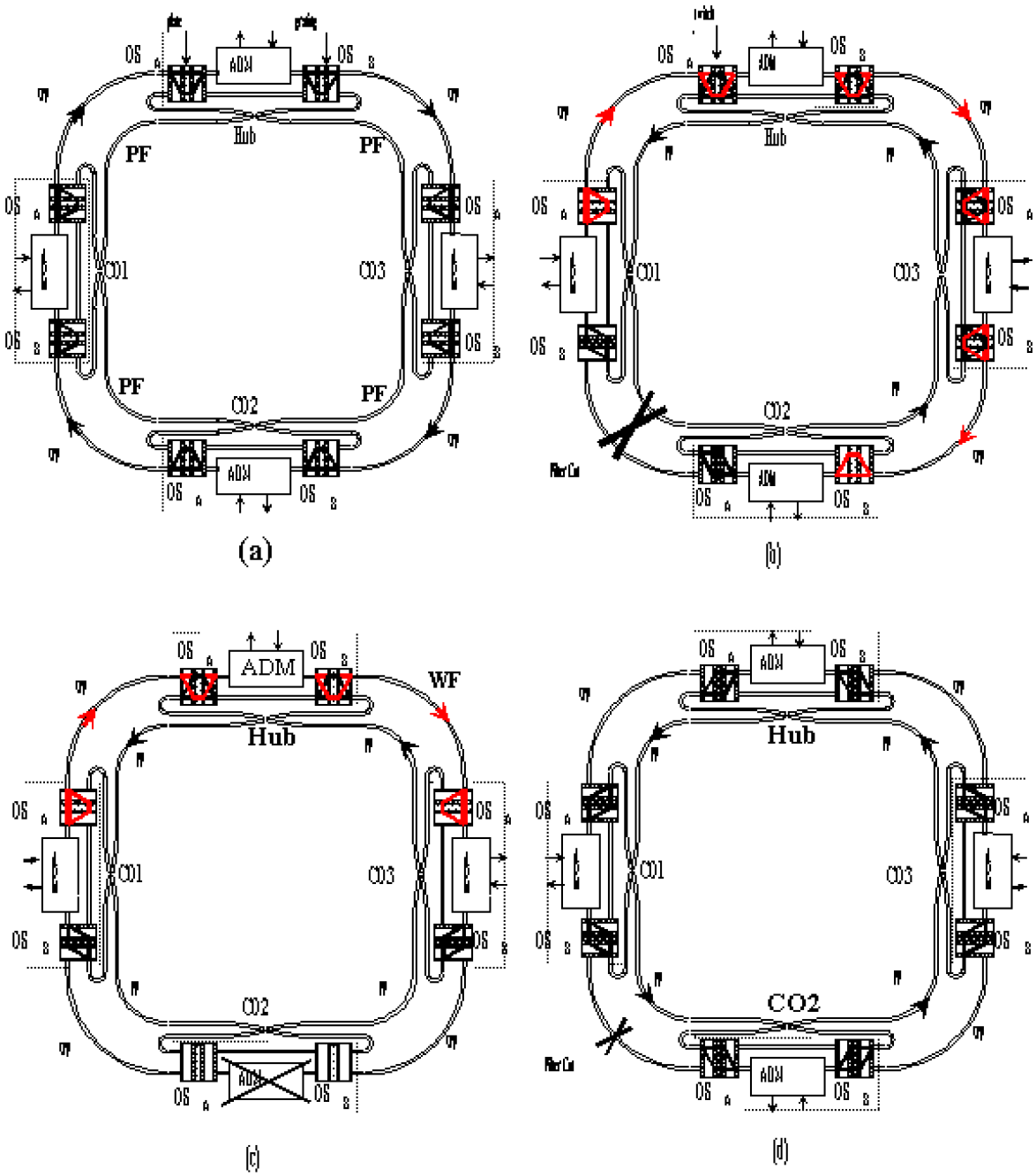


Fig. 4 The structure of (a) a four channel polarization and wavelength separation element, and (b) the staked holograms.

PF: Protection Fiber

OS : Holographic Optical Switch



圖五　Self-Healing Ring using two holographic optical switches at each node (a) Normal operation. (b) Fiber failure between two nodes. (c) Node failure. (d) Working fiber failure.