Optoelectronics and Semiconductor Group

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Field of study: Optoelectronic Integrated Circuits, Submicron SOI Photonics, Biosensors

Key words: SOI (Silicon on Insulator), AWG (Array Waveguide Grating)

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1. The Subject and Aims of Research

Recent research aims at utilizing silicon photonics to monolithically integrate photonics and microelectronics on a SOI chip for size, weight, and cost reduction by eliminating a majority of pigtails and interconnects required in traditional optoelectronic systems.

2. Related Recent Research Topics

(1) Silicon Photonics

The optical waveguides are crucial elements of any scheme involving the loop routing and optoelectronic integration. They are necessary to achieve interconnection of optoelectronic components on a chip as well as chip-to-chip interconnection. Any viable scheme for silicon photonics must include the ability to implement waveguides. The research development study to achieve the high quality optical waveguides is including the single mode region, side wall roughness, propagation loss, bend loss, polarization dependent loss (PDL), birefringence effect, coupling loss, processing variation, waveguide geometry, and power consumption. The optical routing composed by the decent waveguide will be qualified to provide key functions for optical communication technologies, such as optical power splitting, loop signal bus, demultiplexing/multiplexing, switching, and modulating. The system-on-a-chip will be pursued via SOI technology to develop low optical insertion loss on SOI waveguides and other passive and active functional devices

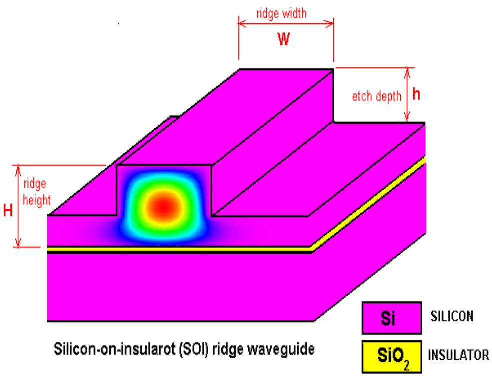
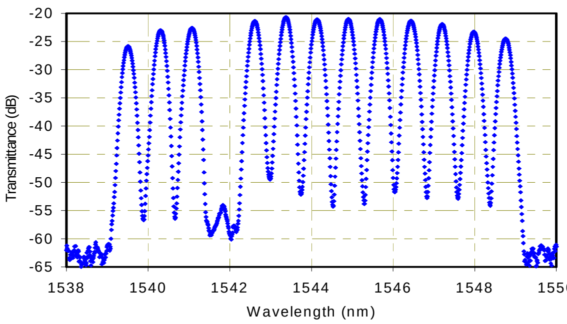


Fig.1 SOI Optical Waveguide Schematic Diagram



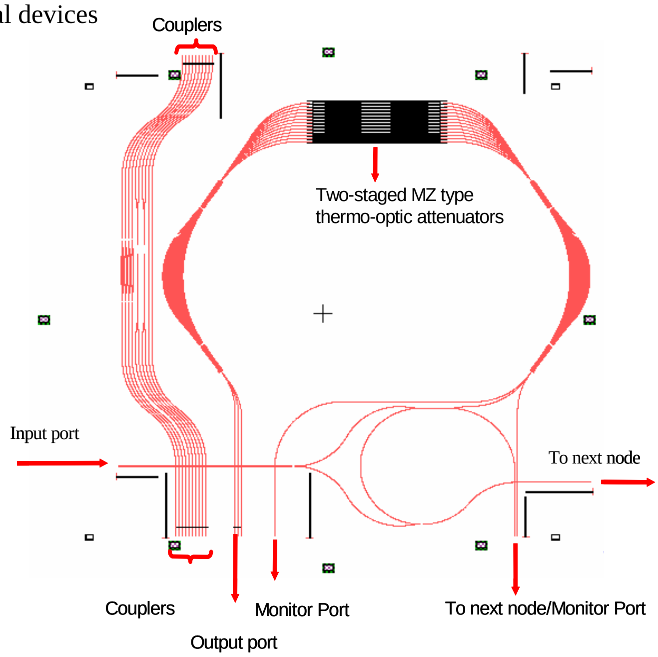


Fig.2 Photonic Bus Layout and Microsecond Optical channel Selection

(2) Submicron Silicon Photonics

When the processing technologies for SOI waveguide based components can be fully compatible with CMOS, the silicon thickness should be reduced to the submicron order. The simulations for TE-like and TM-like polarization modes for 0.3 μm thick silicon wire are shown in Fig. 3(a), which are similar to the experimental images from G. T. Reed in the University of Surrey, UK, as shown in Fig. 3(b). The TE filed profile is characterized by much higher filed intensity at the side walls, whilst the TM mode has a relatively small amplitude at the side walls, but much higher amplitude at the top and bottom interfaces. The submicron silicon photonics own the potential to achieve the monolithic integration of the most efficient data processing platforms (microelectronics) with the most efficient datacom platforms (wavelength division multiplexing photonics).

(a) (b)

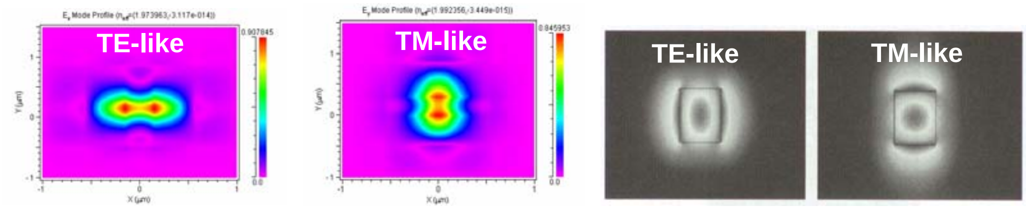


Fig.3 Simulation and Experimental Images for 0.3 μm Thick SOI Waveguides

(3) Building Blocks for Optoelectronic Integrated Circuits

Wavelength division multiplexing (WDM) is rapidly becoming a mainstream technology for high capacity optical communications. The critical components needed in WDM systems are grating based optical filters and multi-wavelength laser array, which are the key building blocks for the long and short haul telecommunications, especially for the fiber to the home (FTTH) networking. An integrated external cavity WDM laser array without regrowth of semiconductor material had been developed. This device was composed of a set of active lasers, a passive SiO_2 waveguide and an etched Rowland circle grating. The wavelength spacing was 1.5 nm over a spectral range from 816.5 nm to 828.5 nm.

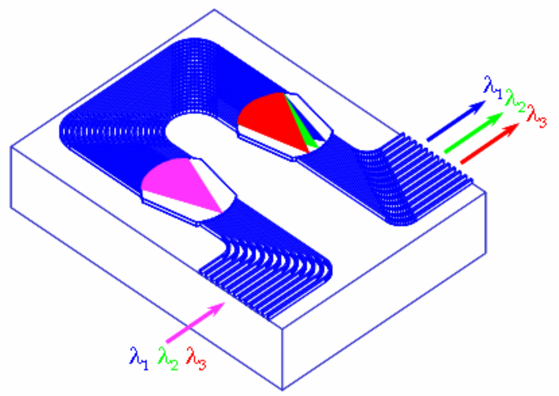


Fig.4 Array Waveguide Grating Schematic Diagram

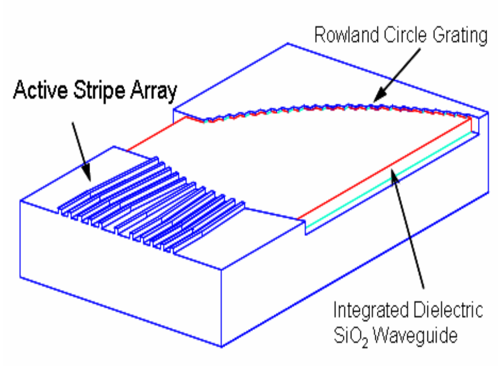


Fig.5 WDM Laser Array

3. Selected Publications and Projects

(1) **S. H. Hsu**, "Polarization-dependent loss compensation on silicon-wire waveguide tap by complex refractive index of metals", ***Optics Letters***, 34(12), pp. 1798-1800, 2009

(2) **S. H. Hsu** and Y.-L. Tsai, "Tapping signal power on 12-μm thick SOI optical waveguide for performance monitoring", ***Electronics Letters***, 45(3), pp. 161-163, 2009

(3) **S. H. Hsu**, "Polarization dependent loss study on silicon-wire waveguide tap for optical performance monitoring", ***OFC2009***, p. JWA13, California, U.S.A.

(4) **S. H. Hsu**, "A 5-μm-thick SOI waveguide with low birefringence and low roughness and optical interconnection using high numerical aperture fiber", ***IEEE Photonics Technology Letters***, 20(12), pp. 1003-1005, 2008

(5) **S. H. Hsu**, and J. Chan, "Photonic bus with loop signal routing and multi-channel wavelength selection on a single silicon-on-insulator platform", ***Optics Letters***, *2006*, 31(14), pp. 2142-2144, 2006

Patent:

(1) **S. H. Hsu**, United States Patent 7,526,146, "Electro-optical modulator and a method for manufacturing the same", US Patent Issued on April 28, 2009

(2) **S. H. Hsu,** D. Feng, C. C. Kung, X. Yin, and G. Coroy, "United States Patent 6,885,795, "Waveguide tap monitor" US Patent Issued on April 26, 2005

Project:

Silicon Photonics from Commercial Applications in Low Birefringence to Highly Integrated Circuits in a Small Footprint (NSC Project), 2008-2010