

3-D Integration of Continuum Generation and Carving on a Silicon Chip

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Abstract: An attempt at creating a multi-wavelength silicon light source is reported. Self phase modulation is used to broaden the spectrum of an off-chip seed pulse. The spectrum is filtered into discrete channels using vertically-coupled microresonators.

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1. Introduction

On-chip optical interconnects have been proposed as alternatives to metal interconnects. They are believed to overcome the latency, the power dissipation and the lack of adequate bandwidth, problems that are exacerbated by the continued scaling of CMOS dimensions. For photonics to offer performance advantages over copper interconnects in terms of bandwidth efficiency per unit area of the chip and latency, it is necessary to use wavelength division multiplexing (WDM) technique that enables the transmission of multiple signals on the same optical interconnect [1, 2]. However, the implementation of WDM using off-chip sources adds significantly to the complexity and cost, as it requires coupling multiple lasers to the chip. Here we demonstrate a method for generating multiple on-chip wavelength sources by using a single off-chip laser. Utilizing self-phase modulation induced spectral broadening in silicon, a continuum of wavelengths is generated from a pico-second seed pulse that is generated off-chip. This continuum is then carved by microdisk resonators, integrated three-dimensionally (3-D) on the chip, to obtain 3 new wavelength sources.

2. Concept and Device Synthesis

The intensity dependent refractive index of silicon leads to self-phase modulation (SPM) and the generation of spectral continuum when intense optical pulses propagate through it. The physical origin of the intensity- dependent refractive index is two fold: (i) Kerr nonlinearity (ii) the modulation of the refractive index of the medium through free carriers generated during the Two Photon Absorption (TPA) process [3]. SPM induced spectral broadening in silicon, and its dependence on various pulse and waveguide properties have been studied previously both experimentally as well as theoretically [3,4]. These spectrally broadened optical pulses may be carved using microdisk based filters that are integrated monolithically with the chip to generate new wavelength channels.

Microdisk filters for carving the continuum are realized on the chip using the SIMOX 3-D sculpting platform that has been reported previously to generate a variety of vertically integrated optical and electronic devices on silicon [5,6]. Briefly, SIMOX 3-D sculpting process involves the implantation of oxygen ions into an SOI substrate that has been patterned with thermally grown oxide. A high temperature anneal after the implantation results in the formation of subterranean waveguide structures separated from a surface silicon layer by a silicon dioxide layer. In this work, subterranean microdisk resonators are realized in this fashion, and the surface silicon layer is used as the seed layer to grow silicon epitaxially on the substrate. After the epitaxial growth, waveguides are etched on the surface silicon layer. A cross-sectional schematic of the device schematic is shown in figure1.

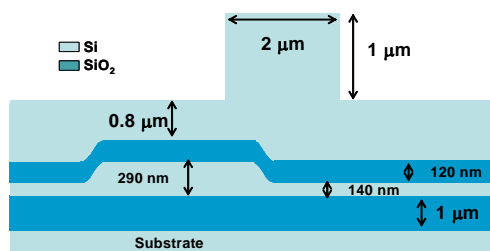


Fig1. Cross-sectional schematic of the 3-D integrated device

Fig2. Optical micrograph of the continuum carving device

