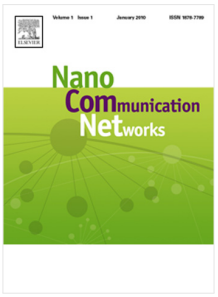
Accepted Manuscript



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PII: S1878-7789(17)30003-0
DOI: http://dx.doi.org/10.1016/j.nancom.2017.06.001
Reference: NANCOM 183

To appear in: *Nano Communication Networks*

Received date : 3 February 2017
Revised date : 17 June 2017
Accepted date : 18 June 2017

Please cite this article as: A.J. Shaikh, O. Sidek, F. Packeer, Self phase modulation and cross phase modulation in nonlinear silicon waveguides for on-chip optical networks - a tutorial, *Nano Communication Networks* (2017), http://dx.doi.org/10.1016/j.nancom.2017.06.001

Self Phase Modulation and Cross Phase Modulation in Nonlinear Silicon Waveguides for On-Chip Optical Networks - A Tutorial

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Keywords: self-phase modulation; cross-phase modulation; nonlinear silicon photonics

Abstract. Silicon is a nonlinear material and optics based on silicon makes use of these nonlinearities to realize various functionalities required for on-chip communications. This article describes foundations of these nonlinearities in silicon at length. Particularly, self phase modulation and cross phase modulation in the context of integrated on-board and on-chip communications are presented. Important published results and principles of working of these nonlinearities are presented in considerable detail for non-expert readers.

1 Introduction

The ultimate goal of any communication system design, whether long-haul or short reach, is to maximize data transmission capacity while maintaining a reasonable level of design and operation cost. The long-haul communication system involves signal transmission and hence data communication through atmosphere via wireless medium or under the sea through fiber optic cables. The short reach data communication, on the other hand, involves signal transmission between two points much less distant. These short reach interconnects are common in big data centers and supercomputing facilities. However, since the inception of multicore processors and multiprocessors systems, the focus of research in the field of interconnect has been shifted primarily towards interconnects of even smaller scale, i.e. intrachip and interchip interconnects. This article will specifically discuss physical processes and their applications in the context of these small scale interconnects.

It is well known that speed of a microprocessor is much faster as compared to the transmission speeds of chipscale interconnects. These slow metallic interconnects, which are responsible for data exchange between processor and memory, result in a situation where a single-core CPU remains mostly idle during the read/write cycles. One can imagine the undesirability of the situation that would arise when multicores are involved. Contemporary multiprocessors system can simply outpace the interconnect transmission speeds and hence are severely underutilized. This underutilization has become more relevant since the paradigm of *big data* got widespread acceptance. The idea of big data relies solely on extracting conclusions and making inferences by simultaneously processing massive data stored in data centers rather than dividing it into smaller subgroups. These data (expanding with a rate of several exabytes per day worldwide) are now not limited to any exotic scientific