The Johns Hopkins University

Whiting School of Engineering
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Nonlinear Optics in Hydrogenated Amorphous Silicon (a-Si:H) Waveguides

Dissertation Defense by

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Abstract

Silicon photonics combines wide-bandwidth capability with well-developed nano-fabrication technology, allowing for short-range communication at low cost, with low operating power and compact device footprints. In order to compete with traditional copper wiring, optical interconnects must be integrated vertically for maximum integration density. Crystalline silicon (c-Si) cannot be deposited; only epitaxially grown thereby destroying the electronic devices and is consequently limited to single layer integration. Here I investigate a new photonic material, hydrogenated amorphous silicon (a-Si:H). This material can be deposited at a low temperature 150~300˚C within CMOS thermal budget and is already available in the current fabrication process line. Furthermore, the nonlinear coefficient of the material is measured to be approximately an order of magnitude higher than c-Si therefore allowing ultra-fast time scale nonlinear application at very low powers.

The first part of this dissertation will focus on the design and fabrication of the a-Si:H waveguide. The optical properties of the waveguide is measured and analyzed. Secondly, using the highly-nonlinear a-Si:H waveguide, I will discuss our demonstrations including: 1) broad-bandwidth wavelength conversion, 2) low power time-domain demultiplexing, 3) all optical signal regeneration, 4) short pulse characterization via frequency resolved optical gating (FROG), 5) broad-band optical parametric amplification and oscillation, and 6) correlated photon-pair generation.

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