Reconfigurable nanophotonic devices using phase-change materials

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ABSTRACT

Nanophotonic integrated circuits enable realizing functional optical devices using efficient design and fabrication routines. Their inherent stability and scalability makes them attractive for applications where optical signal processing is combined with coupling to external light stimuli. A majority of nanophotonic devices is, however, based on passive materials, which do not provide low-power tuning options or knobs for reconfigurability. We address this shortcoming by combining passive silicon nitride photonic devices with tunable phase-change materials [1]. Such a platform allows realizing both on-chip optical data storage [2] and active photonic components.

Implementing on-chip photonic memories has been pursued for a long time, in particular for fabricating memory devices which are able to retain their state after the storage process. Photonic data storage would dramatically improve performance in existing computing architectures by reducing the latencies associated with electrical memories and potentially eliminating optoelectronic conversions. Furthermore, multi-level photonic memories with random access would allow for leveraging even greater computational capability. Thus far, photonic memories have been predominantly volatile, meaning that their state is lost once the input power is removed. We exploit hybrid photonic-phase-change materials to implement robust, non-volatile, all-photonic memories. By using optical near-field coupling within on-chip waveguides, we realize bit storage of up to eight levels in a single device that readily switches between intermediate states. We show that individual memory elements can be addressed using a wavelength multiplexing scheme. Such multi-level, multi-bit devices provide a pathway towards eliminating the von Neumann bottleneck and portend a new paradigm in all-photonic memory and non-conventional computing. We further show that such devices can be operated with short optical pulses, both for write and read operations

Key words: Nanophotonics, integrated optics, phase-change materials.

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