Interferometric switches for transparent networks : development and integration

by

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ABSTRACT

Magneto-optic devices are a potential enabler of better scaling, transparent networks that are bit-rate, protocol and format insensitive. Transparency is critical given the paradigm shift from connection-oriented communications to IP-centric packet switched data traffic driven by the influx of high bandwidth applications. This is made more urgent by the large and growing optical-electronic bandwidth mismatch as well as the rapid approach of device dimensions to the quantum limit.

Fiber-based switches utilizing bismuth-substituted iron garnets as Faraday rotators in Mach-Zehnder and Sagnac interferometer configurations are proposed, analyzed and characterized. The issues and limitations of these switches are investigated and efforts are undertaken to model and optimize the field generating coil impedance parameters. While alleviating the concerns associated with free-space switches and being compatible with contemporary optical networks, the performance of the fiber-based interferometric switches is still below theoretical limits and could be improved. Moreover, the discrete components of a fiber-based implementation engender scalability concerns.

In keeping with the spirit of Richard Feynman's lectures, the maturity of planar lithographic techniques that are widely used in microelectronics is leveraged to realize integrated versions of the fiber-based interferometric switches. The design, analysis, fabrication and characterization of these integrated switches are detailed herein, including the selection of a suitable material system, design of the waveguide geometry, creation and calibration of a fabrication process based on direct-write scanning electron-beam lithography as well as determination of the switches' fabrication tolerance.

While the larger waveguide cross-section of the microphotonic switches enables efficient coupling to fiber and greatly reduces geometrical birefringence, the weak confinement results in longer device lengths. Moreover, the small but finite birefringence induces some polarization dependence in switch performance. Consequently, compact and nominally non-birefringent nanophotonic versions of the interferometric switches are proposed and analyzed in the interest of further improving switch performance and scalability.