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Corralling photons: controlling light in optical waveguides on the chip-scale

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Integrated optics and photonics encompasses the science and engineering of optical guided waves in highly integrated devices, components, circuits, and systems in a manner that is analogous to integrated circuits in electronics. Controlling light on the scale of a microelectronic circuit creates challenges that span design for miniaturization and control of fundamental properties of light, materials for low power consumption and high linearity, and microfabrication for low losses and high efficiency. Three solutions are described in this talk. First, out-of-plane optical waveguides are introduced, allowing for low loss fiber-to-chip light coupling and access to Berrys phase, a quantum-mechanical phenomenon of purely topological origin. As a result, electrically tunable optical polarization rotation on a silicon chip is achieved for the first time using global topological effects. Second, a hybrid material system consisting of both silicon and lithium niobate is presented that enables compact integrated optics on a silicon platform with electro-optic functionality provided by a true second order material susceptibility. The platform enables electrically tunable optical filters, switches, and modulators, as well as radio frequency (RF) electric-field sensors. Finally, periodic structures that harness the dispersion engineered properties of guided wave dielectric structures will be discussed with a focus on the scaling properties of compact resonators. Novel chip-scale photonics are enabled for photon emission, propagation, amplification, storage, and material interaction.