POPULAR SCIENTIFIC ABSTRACT

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Active nanophotonic circuitry based on surface plasmons

This PhD thesis presents investigations of active plasmonic circuitry with high efficiencies designed for compact and ultra-fast conversion of signals between the electrical and optical domain. Owing to a strong enhancement of electromagnetic fields in metal nanostructures and a high field-overlap between the optical and electrostatic fields, the presented plasmonic devices can serve as an alternative to traditional optical telecommunication devices by offering faster device operation at much more compact footprints. The experimental and theoretical studies consider nanophotonic waveguides and couplers based on surface plasmon polaritons, which are collective electron oscillations propagating along a metal-dielectric interface. The nanophotonic circuits are designed and optimized by analytical and numerical methods, and subsequently fabricated by electron beam lithography and thin-film deposition techniques.

The first part of the thesis outlines the development of highly-dense integrated plasmonic circuits, which allow the realization of branchless interferometric systems consisting of two parallel plasmonic waveguides which are excited via ultra-compact antenna couplers. The thesis continues with the development of active plasmonic structures, incorporating optoelectronic phenomena for spin-selective photodetection and electro-optic modulation. The device operation is characterized by their optical and optoelectronic response using optical spectroscopy techniques, revealing a record-high electro-optic efficiency of the proposed plasmonic modulator as compared with competitive devices based on the same material platform. Further studies on utilizing long-range plasmonic waveguides suggests the development of low-loss plasmonic electro-optic modulators. The thesis ultimately arrives at the conclusion that active plasmonic technology can meet the future needs of active integrated circuits and optical communications systems.