Joint ECE/CCT/HITP* Seminar

Modeling of nanophotonic and plasmonic devices

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9:30 – 10:30 AM, Room 117 Electrical Engineering Building

Nanophotonics represents a new regime of optics. The development in this field is leading towards ultra-small and high-speed photonic and optoelectronic devices, which are important for a wide range of optical systems. Computational modeling has enormous impact in the development of nanophotonics. Modeling provides direct guidance in device design, and also unique insights into the device operation through direct visualization of the underlying physical processes. In this talk we review our efforts in developing highly efficient algorithms for modeling nanophotonic structures, and in using them to develop new devices.

For practical implementations of nanophotonic devices, it is of fundamental importance to determine the sensitivity of the device properties to variations of the design parameters. We present a new sensitivity analysis method based upon the adjoint variable method and a frequency-domain solver for Maxwell's equations. In this approach, once a device is simulated, the sensitivity of the device performance with respect to any number of design parameters is calculated with very small additional computational cost. Furthermore, this approach determines the sensitivity with respect to geometrical parameter variations accurately without the need for the use of high-resolution grids.

The development of optical devices that confine and manipulate light at a deep sub-wavelength scale represents a new frontier in nanophotonics. Based on frequency-domain modeling, we introduce a new class of plasmonic waveguides consisting of an air slot in thin metallic films. Such a waveguide supports a truly guided mode, with a modal diameter of approximately 50nm at infrared wavelengths, a huge guiding bandwidth exceeding 100THz, a high group velocity, and a relatively long propagation distance. These characteristics are ideal for many applications in optical interconnect systems.

We also investigate the performance of bends and power splitters in plasmonic slot waveguides. We show that, bends and splitters with near ideal performance can be designed over a wavelength range that extends from microwave to near-infrared, when the bend and splitter dimensions are much smaller than the optical wavelength. We account for this effect with a characteristic impedance model based upon the real dispersion relation of the plasmonic waveguide structures. Finally, we show that light can be coupled efficiently from conventional dielectric waveguides to plasmonic slot waveguides. Combining these works, we believe that plasmonic slot waveguides may provide an important platform for manipulating light at a deep sub-wavelength scale.

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Everyone is invited to attend