Tuning and Control of Surface Plasmon Resonance Sensing Using Grating-Based Nanostructures

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The interaction of light with nanostructured objects, particularly those containing metals, can produce a variety of unique, interesting, and potentially useful optical phenomena. Examples include enhanced optical transmission through nanostructured metals, super focusing through nano-apertures, and optical waveguiding via nanoparticle chains. The origins of many of these optical phenomena can be traced to the excitation and propagation of surface plasmons at nanostructured metal objects. Notably, these surface plasmon effects have also been exploited in a variety of sensing applications. Nanostructure-based plasmonic sensing has been achieved with nanohole arrays, single nanometric holes, nanoslit arrays, and various diffractive nanostructures.

In this presentation, I will describe recent work involving the construction and analysis of diffraction grating couplers for the excitation and sensing of surface plasmons. Gratings provide a unique combination of features that make them promising substrates for the construction of nanoscale optical elements and plasmonic devices. Notably, the ability to control the size (pitch and amplitude), shape (surface profile) and geometry (angle) of gratings allows precise control over the resulting plasmonic features, including the strength of coupling and the details of the optical response, including the shape and location of the optical features. Several examples will be discussed, using both experiment and optical modeling, to investigate the role of various surface features on plasmonic behavior of metal-coated gratings. Examples include enhanced optical transmission through metal-coated gratings, the development of “chirped” diffraction gratings for detailed structural analysis, and the use of dispersion imaging to fully characterize the complexity of the optical response. The ability to combine grating-coupled surface plasmon resonance to other analytical techniques will also be described. Examples include SPR-based imaging of microarrays, grating-coupled SPR in combination with infrared and optical spectroscopy, and electrochemical applications of grating-based SPR detection.