Surface Plasmon Resonance

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Abstract

Surface plasmons are coherent electron oscillations that exist at the interface between any two materials where the real part of the dielectric function changes sign across the interface. Surface Plasmon Resonance (SPR) can be used to detect molecular adsorption on surfaces and consequently is of significance for technologies ranging from gene assays and DNA sensing, molecular adsorption and desorption on surfaces, surface controlled electrochemical reactions, and nano-scale optical and photonic devices. SPR technology is based on the electromagnetic field component of incident light penetrating tens of nanometers into a surface. The stimulated resonance oscillation of valence electrons reduces the reflected light intensity and produces SPR due to the resonance energy transfer between the evanescent wave and surface plasmons. The resonance conditions are influenced by the type and amount of material adsorbed onto the surface thus allowing characterization of surface related phenomena. Two typical configurations of plasmon excitation exist: the Kretschmann-Raether configuration, in which a thin metal film is sandwiched between a dielectric and air, and the incident wave is from the dielectric side; and the Otto configuration, where an air gap exists between the dielectric and the metal. In both cases, the surface plasmon propagates along the metal/dielectric interface. The Kretschmann-Raether configuration is easier to fabricate but has a fixed dielectric gp that can affect the sensitivity of the measurement. Full insight into surface plasmon resonance requires quantum mechanics considerations. However, it can be also described in terms of classical electromagnetic theory by considering electromagnetic wave reflection, transmission, and absorption for the multi-layer medium. In fact the excitation of plasmon resonance can only take place if the metal side of the interface is slightly lossy, i.e. when the imaginary part of the metal permittivity is a non-zero negative number. These two configurations for SPR have been analyzed using COMSOL Multiphysics to define the effect of the SPR on the electromagnetic field. The angle of resonance is sensitive to both the experimental configuration used and to the dielectric constant of the material adjacent to the metal surface. Using the analytical approaches demonstrated the effect of different surface and experimental configurations on the SPR response can be defined and has allowed the development of commercial technology for the measurement of surface contaminants and nano-scale photonic devices.