17.1. INTRODUCTION

Metallic particles and surfaces display diverse and complex opto-electrical properties. These properties, such as intense colors of noble metal colloids, strongly depend on metal and colloid size, and have been a subject of studies for centuries. Thin metal surfaces display strong absorption of light impinging under a very well defined angle that strongly depends on physicochemical properties of dielectrics on both sides of the metal film. For the last 20 years surface plasmon resonance (SPR) technology has been widely utilized in biochemical and biophysical analyses and is now extensively used for studying bioaffinity reactions on surfaces.\(^1\)\(^-\)\(^5\) A typical experimental configuration for SPR analysis is shown in Fig. 17.1. A thin metal film (typically gold or silver \(\sim 50\) nm thick) is illuminated through the glass prism at an angle \(\theta\). The electromagnetic light wave induces a periodic oscillating electric field that forces collective planar oscillations of free charges in the metal film (surface plasmons). At a very precisely defined angle, when the lateral component of the impinging light wavevector, \(k\), matches the wavevector of the surface plasmons \(k_{sp}\), these surface plasmon oscillations are in resonance with the frequency of the incident light. Under these conditions an electromagnetic field efficiently couples to the surface plasmons, which results in highly attenuated light reflection. This phenomenon (SPR) is extremely sensitive to small changes of the dielectric constant above the metal film and has been used to measure biomolecule binding to surfaces, as in the Biacore apparatus (http://www.biacore.com).

Excited surface plasmons in the metal film create highly enhanced evanescent fields penetrating the dielectric above the metal surface up to several hundred nanometers.
into the sample, see Fig. 17.1. Conversely, excited fluorophores present within this distance from the surface create an electromagnetic field that may strongly interact with free charges in the metal film inducing surface plasmons. The frequency of these plasmons corresponds to the emission frequency of the fluorophores. As a result, we observe a strong directional emission, which we call Surface Plasmon Coupled Emission (SPCE) (Fig. 17.2). The resulting SPCE exhibits the same spectral shape as the fluorophore emission, but is highly polarized with a sharply defined emission angle back into the glass substrate. A technology based on SPCE may provide 50% light collection efficiency and high intrinsic wavelength resolution with the use of a very simple optics. Such desirable properties can result in wide range of simple, inexpensive and robust devices of general use to biology and medicine. We stress that

\[ \text{Figure 17.1. SPR configuration. At the } \theta_{sp} \text{ angle the reflectivity is strongly attenuated.} \]

\[ \text{Figure 17.2. Concept of surface plasmon-coupled emission (SPCE). F represents a fluorophore. The excitation energy of the fluorophore couples to surface plasmons and radiates into the glass prism.} \]