Preface

Plasmonics forms a major part of the fascinating field of *nanophotonics*, which explores how electromagnetic fields can be confined over dimensions on the order of or smaller than the wavelength. It is based on interaction processes between electromagnetic radiation and conduction electrons at metallic interfaces or in small metallic nanostructures, leading to an enhanced optical near field of sub-wavelength dimension.

Research in this area demonstrates how a distinct and often unexpected behavior can occur (even with for modern optical studies seemingly uninteresting materials such as metals!) if discontinuities or sub-wavelength structure is imposed. Another beauty of this field is that it is firmly grounded in classical physics, so that a solid background knowledge in electromagnetism at undergraduate level is sufficient to understand main aspects of the topic.

However, history has shown that despite the fact that the two main ingredients of plasmonics - *surface plasmon polaritons* and *localized surface plasmons* - have been clearly described as early as 1900, it is often far from trivial to appreciate the interlinked nature of many of the phenomena and applications of this field. This is compounded by the fact that throughout the 20th century, surface plasmon polaritons have been rediscovered in a variety of different contexts.

The mathematical description of these surface waves was established around the turn of the 20th century in the context of radio waves propagating along the surface of a conductor of finite conductivity [Sommerfeld, 1899, Zenneck, 1907]. In the visible domain, the observation of *anomalous* intensity drops in spectra produced when visible light reflects at metallic gratings [Wood, 1902] was not connected with the earlier theoretical work until mid-century [Fano, 1941]. Around this time, loss phenomena associated with interactions taking place at metallic surfaces were also recorded via the diffraction of electron beams at thin metallic foils [Ritchie, 1957], which was in the 1960s then linked with the original work on diffraction gratings in the optical domain [Ritchie et al., 1968]. By that time, the excitation of Sommerfeld's surface waves with visible light using prism coupling had been achieved [Kretschmann and Raether, 1968], and a unified description of all these phenomena in the form of surface plasmon polaritons was established.

From then on, research in this field was so firmly grounded in the visible region of the spectrum, that several rediscoveries in the microwave and the terahertz domain took place at the turn of the 21st century, closing the circle with the original work from 100 years earlier. The history of localized surface plasmons in metal nanostructures is less turbulent, with the application of metallic nanoparticles for the staining of glass dating back to Roman times. Here, the clear mathematical foundation was also established around 1900 [Mie, 1908].

It is with this rich history of the field in mind that this book is written. It is aimed both at students with a basic undergraduate knowledge in electromagnetism or applied optics that want to start exploring the field, and at researchers as a hopefully valuable desk reference. Naturally, this necessitates an extensive reference section. Throughout the book, the original studies described and cited were selected either because they provided to the author's knowledge the first description of a particular effect or application, or due to their didactic suitability at the point in question. In many cases, it is clear that also different articles could have been chosen, and in some sections of the book only a small number of studies taken from a pool of qualitatively similar work had to be selected.

The first part of this text should provide a solid introduction into the field, starting with an elementary description of classic electromagnetism, with particular focus on the description of conductive materials. Subsequent chapters describe both surface plasmon polaritons and localized plasmons in the visible domain, and electromagnetic surface modes at lower frequencies. In the second part, this knowledge is applied to a number of different applications, such as plasmon waveguides, aperture arrays for enhanced light transmission, and various geometries for surface-enhanced sensing. The book closes with a short description of metallic metamaterials.

I hope this text will serve its purpose and provide a useful tool for both current and future participants in this area, and will strengthen a feeling of community between the different sub-fields. Comments and suggestions are very much appreciated.

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Springer

http://www.springer.com/978-0-387-33150-8

Plasmonics: Fundamentals and Applications
Maier, S.A.
2007, XXVI, 224 p., Hardcover
ISBN: 978-0-387-33150-8