

Plasmonic Nanoelectronics and Sensing

Plasmonic nanostructures provide new ways of manipulating the flow of light, with nanostructures and nanoparticles exhibiting optical properties never before seen in the macro-world. Covering plasmonic technology from fundamental theory to real-world applications, this work provides a comprehensive overview of the field.

- Discusses the fundamental theory of plasmonics, enabling a deeper understanding of plasmonic technology
- Details numerical methods for modeling, design, and optimization of plasmonic nanostructures
- Includes step-by-step design guidelines for active and passive plasmonic devices, demonstrating the implementation of real devices in the standard CMOS nanoscale electronic–photonic integrated circuit to help cut design, fabrication, and characterization time and cost
- Includes real-world case studies of plasmonic devices and sensors, explaining the benefits and downsides of different nanophotonic integrated circuits and sensing platforms.

Ideal for researchers, engineers, and graduate students in the fields of nanophotonics and nanoelectronics as well as optical biosensing.

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Contents

| | | |
|----------|--|----------------|
| | <i>List of contributors</i> | <i>page</i> ix |
| | <i>Preface</i> | xi |
| 1 | Fundamentals of plasmonics | 1 |
| 1.1 | Electromagnetic field equations | 1 |
| 1.1.1 | Maxwell’s equations in a medium | 1 |
| 1.1.2 | Material equations | 2 |
| 1.1.3 | Temporal and spatial dispersion in metals | 4 |
| 1.2 | The local-response approximation | 6 |
| 1.2.1 | The energy of an electromagnetic field in metals | 6 |
| 1.2.2 | Properties of the complex dielectric permittivity | 7 |
| 1.2.3 | The conduction-electron contribution | 8 |
| 1.2.4 | The bound-charge contribution | 10 |
| 1.3 | Electromagnetic fields in metals | 14 |
| 1.3.1 | Plasmon classification | 14 |
| 1.3.2 | Bulk plasmon modes | 17 |
| 1.3.3 | Surface plasmon modes | 18 |
| | References | 19 |
| 2 | Plasmonic properties of metal nanostructures | 20 |
| 2.1 | Plasmonic modes in spherical geometry | 20 |
| 2.1.1 | Spherical harmonics | 20 |
| 2.1.2 | Electromagnetic fields in vector spherical harmonics | 22 |
| 2.1.3 | Spherical plasmons | 23 |
| 2.1.4 | Scattering by a sphere | 26 |
| 2.1.5 | Cross-sections | 28 |
| 2.1.6 | A multilayer sphere | 32 |
| 2.2 | Plasmonic modes in cylindrical geometry | 35 |
| 2.2.1 | Cylindrical harmonics | 35 |
| 2.2.2 | Electromagnetic fields in vector cylindrical harmonics | 36 |
| 2.2.3 | Cylindrical plasmon polaritons | 38 |
| 2.2.4 | Scattering by a cylinder | 40 |
| 2.2.5 | Cross-sections per unit length | 43 |
| 2.2.6 | Multilayer cylinder | 46 |

| | | |
|----------|---|------------|
| vi | Contents | |
| | | |
| | 2.3 Plasmonic modes in planar geometry | 49 |
| | 2.3.1 Planar harmonics | 50 |
| | 2.3.2 Electromagnetic fields in vector planar harmonics | 51 |
| | 2.3.3 Planar plasmon polaritons | 52 |
| | 2.3.4 Reflection and transmission by a slab | 56 |
| | 2.3.5 Reflectance, transmittance, and absorptance | 58 |
| | 2.3.6 A multilayer slab | 60 |
| | References | 65 |
| 3 | Frequency-domain methods for modeling plasmonics | 67 |
| | 3.1 Introduction | 67 |
| | 3.2 Rigorous coupled-wave analysis | 68 |
| | 3.2.1 Formulations | 68 |
| | 3.2.2 Modeling 2D and 3D plasmonic nanostructures with RCWA | 79 |
| | 3.3 A semi-analytical method for near-field coupling study | 87 |
| | 3.3.1 Superlens and subwavelength imaging | 87 |
| | 3.3.2 Object–superlens coupling | 87 |
| | 3.4 Summary | 95 |
| | References | 95 |
| 4 | Time-domain simulation for plasmonic devices | 99 |
| | 4.1 Introduction | 99 |
| | 4.2 Formulation | 101 |
| | 4.2.1 A model for metals | 101 |
| | 4.2.2 A model for solid-state materials | 107 |
| | 4.2.3 Simulation of an MSM waveguide and a microcavity | 111 |
| | 4.2.4 SPP generation using an MSM microdisk | 114 |
| | 4.3 Surface plasmon generation in semiconductor devices | 120 |
| | 4.4 Implementation of the LD model on a GPU | 125 |
| | 4.4.1 GPU implementation | 127 |
| | 4.4.2 Applications | 130 |
| | 4.5 Summary | 134 |
| | References | 135 |
| 5 | Passive plasmonic waveguide-based devices | 139 |
| | 5.1 Introduction | 139 |
| | 5.2 The vertical hybrid Ag–SiO ₂ –Si plasmonic waveguide and devices based on it | 142 |
| | 5.2.1 Theoretical background | 142 |
| | 5.2.2 The dependence of the propagation characteristics on the thickness of the SiO ₂ stripe | 143 |

| | Contents | vii |
|----------|---|------------|
| 5.2.3 | The dependence of the propagation characteristics on the dimensions of the Si nanowire | 144 |
| 5.2.4 | The propagation characteristics of the vertical hybrid, metal–insulator–metal, and dielectric-loaded plasmonic waveguides | 147 |
| 5.2.5 | Waveguide couplers | 149 |
| 5.2.6 | Waveguide bends | 151 |
| 5.2.7 | Power splitters | 153 |
| 5.2.8 | Ring resonator filters | 155 |
| 5.3 | Complementary metal–oxide–semiconductor compatible hybrid plasmonic waveguide devices | 159 |
| 5.3.1 | CMOS-compatible plasmonic materials | 160 |
| 5.3.2 | Vertical hybrid Cu–SiO ₂ –Si plasmonic waveguide devices | 161 |
| 5.3.3 | Horizontal hybrid Cu–SiO ₂ –Si–SiO ₂ –Cu plasmonic waveguide devices | 165 |
| | References | 176 |
| 6 | Silicon-based active plasmonic devices for on-chip integration | 180 |
| 6.1 | Introduction | 180 |
| 6.2 | Plasmonic modulators based on horizontal MISIM plasmonic waveguides | 182 |
| 6.2.1 | The operating principle | 182 |
| 6.2.2 | Experimental demonstration | 186 |
| 6.2.3 | Issues and possible solutions | 189 |
| 6.3 | Athermal ring modulators based on vertical metal–insulator–Si hybrid plasmonic waveguides | 191 |
| 6.3.1 | Device structure | 191 |
| 6.3.2 | Device properties | 192 |
| 6.3.3 | Tolerance | 200 |
| 6.4 | Schottky-barrier plasmonic detectors | 201 |
| 6.4.1 | Device structure | 201 |
| 6.4.2 | SPP power absorption | 202 |
| 6.4.3 | Quantum efficiency | 204 |
| 6.4.4 | Dark current and speed | 207 |
| 6.5 | Metallic nanoparticle-based detectors | 208 |
| 6.5.1 | Device structure | 208 |
| 6.5.2 | LSPR-enhanced absorption | 208 |
| 6.5.3 | Experimental demonstration | 210 |
| 6.5.4 | Issues and solutions | 212 |
| 6.6 | Conclusions | 213 |
| | References | 214 |

| | | |
|----------|---|------------|
| viii | Contents | |
| 7 | Plasmonic biosensing devices and systems | 217 |
| 7.1 | Introduction | 217 |
| 7.2 | Plasmonic sensing mechanisms | 219 |
| 7.2.1 | Resonance conditions for sensing | 219 |
| 7.2.2 | Sensitivity and figure of merit | 220 |
| 7.3 | Plasmonic biosensing systems | 222 |
| 7.3.1 | Sensor structures | 222 |
| 7.3.2 | Modulation methods | 226 |
| 7.3.3 | Bio-functionalization formats | 227 |
| 7.4 | Design methods | 228 |
| 7.4.1 | The N -layer model | 228 |
| 7.4.2 | The FEM model | 229 |
| 7.5 | Plasmonic biosensor design examples | 233 |
| 7.5.1 | Graphene-based biosensor design | 233 |
| 7.5.2 | Messenger RNA detection | 237 |
| 7.5.3 | Point-of-care clinical screening of PSA | 241 |
| | References | 247 |
| | <i>Index</i> | 249 |

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Preface

Data communication and information processing are driving the rapid development of ultra-high speed and ultra-compactness in nano-photo-electronic integration. Plasmonics technology has in recent years demonstrated the promise to overcome the size mismatch between microscale photonic and nanoscale electronic integration, and it likely will be crucial for the next generation of on-chip optical nano-interconnects, enabling the deployment of small-footprint and low-energy integrated circuitry.

The phenomenon of surface plasmons was first observed in the Lycurgus cup, which is a Roman glass cage cup in the British Museum, London, UK. This special cup is made of a dichroic glass that shows a different color depending on the condition of illumination. Specifically, in daylight, the cup appears to have a green color, which means that light is being reflected from the cup; however, when a light is shone into the cup and transmitted through the glass, it appears to have a red color. Today, we know that this fascinating behavior is due to nanoscopic-scale gold and silver particles embedded in the glass. However, it took 1500 years and doubtless countless fantastic interpretations for a plausible explanation to emerge. In the last few decades, the phenomenon of surface plasmons has been extensively studied both theoretically and experimentally, and there have been attempts to use it for various applications ranging from solar-cell energy and sensing to nanophotonic devices.

This book presents the results from many years of our collective research in the fields of nanoplasmonics and its applications. It presents state-of-the-art plasmonics device modeling and design techniques, with novel developments in particular in CMOS-compatible integrated circuits and sensing technologies. We hope this book can serve as a good basis for further progress in this field, both in academic research and for industrial applications. The book consists of seven chapters, contributed by Yuriy Akimov, Zhengtong Liu, Iftikhar Ahmed, Eng Huat Khoo, Er-Ping Li, Hong-Son Chu, Wu Lin, and Bai Ping, from the Department of Electronics and Photonics, Institute of High Performance Computing, Singapore, and Shiyang Zhu, Patrick Guo-Qiang Lo, and Dim-Lee Kwong from the Institute of Microelectronics, Agency for Science Technology and Research, Singapore.

Chapter 1 introduces the fundamentals of plasmonics associated with Maxwell's theory and applications in plasmonics. Chapter 2 provides an introduction to the plasmonic properties of metal nanostructures. Chapter 3 presents the modeling and simulation of plasmonics associated with plasmonic devices by implementation of frequency-domain numerical methods. In Chapter 4, time-domain simulation methods, in

particular the finite-difference time-domain method, are introduced for passive and active plasmonic device design. Chapter 5 describes the development of various passive plasmonic waveguides, in particular CMOS-compatible devices for on-chip nanoelectronic integration, and Chapter 6 presents CMOS-compatible active plasmonic devices for on-chip nanoelectronic integration. Both theoretical studies and experimental results are presented in these two chapters. The recent development of plasmonics for biosensing applications is presented in Chapter 7.

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We hope that this book will serve as a valuable reference for engineers, researchers, and post-graduate students in the fields of nanophotonics and nanoelectronics as well as optical biosensing. Even though much has been accomplished in these fields, we predict that many more exciting challenges will arise in these areas.

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