Plasmonic resonators, composed of metallic micro- and nanostructures, belong to the category of excited-state physics on resonances from gigahertz to petahertz. Dynamical physics is in contrast to ground-state physics, which includes thermal states, and is connected to diverse applications to enhance existing photo-induced effects and phenomena such as plasmon-enhanced photoluminescence and Raman scattering. This book has three main aims: to provide fundamental knowledge on plasmonic resonators, to explain diverse plasmonic resonators, and to stimulate further development in plasmonic resonators.

Plasmon-related studies, which are sometimes called plasmonics and include a substantial portion of metamaterials, have shown significant development since the 1980s. The piled-up results are too numerous to study from the beginning, but this book summarises those results, including the history (past), all the possible types of plasmonic resonators (present), and their wide range of applications (future). It provides the basics of plasmons and resonant physics for undergraduate students, the systematic knowledge on plasmonic resonator for graduate students, and cutting-edge and in-depth information on plasmon-enhancement studies for researchers who are not experts in plasmonics and metamaterials, thereby benefitting a wide range of readers who are interested in the nanotechnology involving metallic nanostructures.

Packed with concise yet informative descriptions of the theoretical (classical and quantum mechanical) framework of excited physics and all the possible kinds of plasmonic resonators or structures, this is a definitive textbook on plasmons written from a unified viewpoint.

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Plasmonic Resonators
Plasmonic Resonators
Fundamentals, Advances, and Applications

Masanobu Iwanaga

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To my family

with thanks for longtime support
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Preface

Plasmonic resonators, composed of metallic micro- and nano-structures, belong to category of excited-state physics on resonances at gigahertz to petahertz. Dynamical physics is in contrast to ground-state physics that includes, in a wide sense, thermal states.

Considering the above feature, this book has three main aims.

1. To provide fundamental knowledge on plasmonic resonators. Optical properties in metals, Maxwell equations, and fundamental physical theory on resonances, i.e., response function theory are described. In addition, the history of plasmonic resonators is addressed.
   
   Chapters 1, 2, and 4 are mostly devoted to this purpose.

   This part will be useful for students.

2. To convey information about the diverse plasmonic resonators. The field of plasmonic resonators is already quite developed, and this fact seems to suggest that there is not much room left to find new types of plasmonic resonators. Therefore, this book is most likely enough to know the possible types of plasmonic resonators.
   
   Chapter 3 is responsible for this purpose and is based on experimentally examined plasmonic resonators.

   This part will be informative for a wide range of readers.

3. To stimulate further development on plasmonic resonators. Plasmonic resonators have already attained several examples realizing significant plasmon-enhanced effects.
   
   Chapter 5 mainly addresses experimental results, which are more than the simple electric-field enhancement and are based on more in-depth strategies. This direction, I expect, will enable researchers to achieve substantial progress in the next 5 years or so.
Chapter 6 provides a summary and discusses the future prospects related to plasmonic resonators.

This part will be a starting point to (near) future establishments on plasmonic resonators.

More specifically, this book is organized as follows.

- Chapter 1 describes the basics of plasmonic resonators such as optical properties of metals and surface plasmon polariton and surveys the history of plasmon studies in which metallic thin films, gratings, extraordinary transmission, and metamaterials appear.
- Chapter 2 is devoted to response functions in view of both classical and quantum mechanics. Configuration-interaction theory is also addressed with some analyses based on the Fano resonances.
- Chapter 3 addresses the various plasmonic resonators that have been found to date. A new class of plasmonic resonators, termed stacked complementary (SC) plasmonic resonators, is also included.
- Chapter 4 is devoted to nonlocal responses by metal and plasmons, and to optical nonlocality in plasmonic resonators.
- Chapter 5 describes the recent advances in various plasmonic enhancement, designated as Plas*, and in a few applications.
- Chapter 6 is devoted to future perspectives, which are awaiting challenges in the near future.

I hope that readers will grasp the basics of plasmonic resonators and that this book will help the readers contribute to the diverse applications in the near future. The book does not provide the conclusions on plasmonic resonators but intends to stimulate further advances based on the progress to date. On finishing this manuscript, I realize that there is much room for plasmonic resonators to develop.

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