Preface

By a long-term evolution, biological species have developed numerous powerful structures and functions to survive the natural selection process. These natural designs always present inspirations for solving complex human problems. Early imitations of biological structures can be traced back to six centuries ago, when Leonardo da Vinci tried to fabricate a "flying machine" by studying the anatomy and flight of birds. However, although scientists have never stopped artificially imitating nature (*biomimetics*), many natural designs still surpass the most advanced human products in complexity and functionality.

Over a decade ago, however, a group of new materials, morphology genetic materials, was developed (Cook et al., Angew Chem Int Ed 2003, 42, p. 557). Using a great variety of chemical and physical methods, scientists directly replicated the bio-structures in functional components. These materials not only preserve the original biological morphologies, but also have a broad range of manually endowed functions.

As a part of these studies, this book mainly demonstrates how natural butterfly wing scales can be used to produce advanced SERS substrates. These scales feature 3D sub-micrometer structures that are superior to many human designs in terms of structural complexity, reproducibility, and cost. Moreover, there are globally over 174,500 species of butterflies and moths and each bears various types of scales. This fact presents much freedom for researchers to select appropriate structures according to different applications.

This book presents three approaches for replicating natural butterfly wing scales using a variety of metals required by state-of-the-art science and technology. Among these methods, a single versatile chemical route (Chap. 3) can be used to produce butterfly scales in seven different metals (Ag, Au, Cu, Co, Ni, Pd, and Pt). Significantly, the Au scales such as SERS substrates have ten times the analyte detection sensitivity and are one tenth the cost of their human-designed commercial counterparts (Klarite^{TM}). Since some species of butterflies and moths (e.g., silk moth) have been farmed for thousands of years and one wing usually bears over 100,000 scales, these materials are promising in SERS applications. In addition, preliminary mechanisms of these surface-enhancement phenomena are also included in this book, which have been applied in designing artificial arrays with high SERS performance (Jeon et al., Small 2014, 10, p. 1490).

The main contents of this book are based on the studies conducted in the past 5 years in the Morphology Genetic Lab established by Prof. Di Zhang at Shanghai Jiao Tong University. These replications of butterfly scales to metals were carried out after the first metal butterfly made via PVD in the Vukusic group at the University of Exeter (Garrett et al., J Biophoton 2009, 2, p. 157). We greatly appreciate Mr. Xiang Ding, Mrs. Jing Fang, Mrs. Guofen Song, and Mr. Wenshu Chen for editing the drafts. We would also like to thank the financial support from the Natural Science Foundation of China (No. 51202145, No. 51171110, No. 51271116, and No. 91333115), Shanghai Science and Technology Committee (No. 14JC1403300 and No. 14520710100), and Research Fund for the Doctoral Program of Higher Education of China (20120073120006 and 20120073130001). In addition, I appreciate the support provided by the Program for New Century Excellent Talents in University, Ministry of Education, China.

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