

Preface

Diamond, as a wide bandgap semiconducting material, has been extensively studied for years. For more than 25 years, diamond has been known as a perfect material for mechanical, optical, thermal, and electronic applications due to its excellent physical and chemical properties. High temperature electronic devices, radiation detectors, high voltage switches, X-ray windows, audio speaker diaphragms, and protective coatings are examples of diamond-based devices. In the initial stage of diamond research, natural diamond crystals and single-crystalline diamond synthesized by the high-temperature/high-pressure (HPHT) were mostly utilized. About 30 years ago, the realization of the low-pressure chemical vapor deposition (CVD) of diamond triggered novel aspects of diamond research in laboratories and in industries all over the world. CVD-grown diamond films offer advantages for electronic applications with respect to crystal purification and doping for p-type or n-type conductivity. For example, the diamond films become electrically conductive when they are heavily doped with boron. Such boron-doped diamond films possess wide potential window, low background current, and long stability. They are, therefore, recognized as the perfect electrodes in the fields of electroanalysis, pollution degradation, electrosynthesis, electrochemical biosensing, and so on.

This book is dedicated to presenting reviews of novel aspects in diamond research and technology, which were realized and appeared very recently. These novel topics and technologies accelerate the breakthrough of diamond research in fundamental studies as well as in industrial applications. In this book, five aspects have been selected: CVD diamond growth (Chaps. 1 and 2), surface chemistry of diamond (Chaps. 3 and 4), surface nanostructuring of diamond (Chaps. 5 and 6), applications of diamond for energy and power devices (Chaps. 7 and 8), and diamond based electrochemical sensing devices (Chaps. 9 and 10).

Chapter 1 deals with the growth of diamond using chemical vapor deposition (CVD) techniques, emphasizing the technologies for the homoepitaxial growth of high-quality single-crystal diamond films with atomically flat surfaces. The growth mechanism and control of homoepitaxial diamond growth is discussed. Chapter 2 summarizes the preparation, properties, and applications of diamond composite films with β -SiC. Control of the crystallinity, orientation, and phase distribution of

diamond and SiC are shown. This composite film possesses advantages of both diamond and β -SiC. Their applications as a DNA biosensing platform are demonstrated.

Chapter 3 focuses on the effect of adsorbed species on the chemical and electronic properties of diamond. Theoretical modeling and mathematic simulation clarify the roles of surface terminations of diamond on its surface reactivity, surface processes including surface stability, modification, and functionalization. Growth mechanisms of thin diamond film and surface electrochemistry of diamond are discussed. Chapter 4 reviews surface chemistry of nanodiamonds, which is tunable via surface terminations and surface charges of diamond nanoparticles. The link between surface chemistry, surface charge, and colloidal properties of nanodiamonds is particularly emphasized. Developments of bio-applications of nanodiamonds are summarized. The challenges for nanodiamond-based biomedicine are discussed.

Chapter 5 summarizes various synthetic methods to prepare diamond nanowires. The mechanical, electron field emission, structural stability, electrochemical properties of such one-dimensional diamond nanowires are reviewed. Several physical and electrochemical applications of diamond nanowires have been demonstrated. Chapter 6 presents surface nanostructuring via depositing different nanoparticles. Two types of structured diamond electrodes are demonstrated: nanoparticle-modified diamond electrodes and detonation nanodiamond-based electrodes. Their construction, modification, and physical characteristics are reviewed. The discussion about the progress on the interactions between metals and diamond at nanoparticle-based electrodes is highlighted.

Chapter 7 summarizes the electrochemical applications of diamond films for energy storage and conversions. The techniques used for surface modification of diamond materials are summarized. The applications of such electrode systems for proton exchange membrane fuel cells (methanol and ethanol oxidation) are shown. The production of porous diamond films and their applications for electrochemical capacitors are described. Chapter 8 reviews the electron emission properties of hydrogen-terminated diamond surfaces with a negative electron affinity. The recent development of electron emitters based on diamond *PN* and *PIN* junctions and their application for a high voltage vacuum power switch are presented.

Chapter 9 overviews the technologies to fabricate and characterize diamond microelectrode, ultramicroelectrode, and nanoelectrode, and their arrays. The beneficial characteristics of individual micro-/nano-electrodes and arrays are discussed. Their applications such as sensitive detection of dopamine, surface sensitive detections are demonstrated. Chapter 10 takes the device of diamond microelectrode as an example to demonstrate diamond-based devices for in vivo biosensing applications. The development of boron-doped diamond as electrode material leads to significant improvement toward sensitivity, reproducibility, and stability during the in vivo monitoring of electroactive species. The most recent developments in monitoring of dopamine and glutathione using diamond microelectrodes are described.

It is hoped that these chapters present novel aspects of diamond researches achieved and appeared recently. We believe that this book will simulate more researchers from universities, research institutions, and industrials to contribute and promote diamond related researches in different fields.

Siegen, Germany

Nianjun Yang

Novel Aspects of Diamond
From Growth to Applications

Yang, N. (Ed.)

2015, XVI, 325 p. 153 illus., 33 illus. in color., Hardcover

ISBN: 978-3-319-09833-3