Preface

Liquid crystals (LCs) represent a fascinating state of matter which combines order and mobility at different hierarchical levels, i.e. from nanoscale to macroscale or in other words from molecular level to macroscopic levels. This unique combination enables such system to respond to different external stimuli such as temperature, magnetic field, electric field, mechanical stress, light, chemical reaction, and electrochemical reaction by finding a new configuration of minimum energy. Due to their dynamic nature, liquid crystalline nanostructures efficiently transmit and amplify information and properties over macroscopic scales. The responsive nature and diversity of LCs provide tremendous opportunities as well as challenges for insights in fundamental science, and open the door to numerous practical applications. Conventional nematic LCs have become the quintessential materials of the LC displays (LCDs) with annual more than $100 billion market and have drastically revolutionalized the way that we present information. With the LC displays ubiquitous in our daily life, the research and development of LCs are moving rapidly into the forefront of nanoscience and nanotechnology. With the advent of highly sophisticated instruments and techniques, the self-organized nanostructures of LCs can be probed in multiple dimensions and over different length scales and help in unraveling the structure-property relationships to an unprecedented level. Similarly, the development of devices with nanoscale control of morphologies has provided useful guidelines to design new materials with targeted properties and functionality. Recently, the nanoconfinement and nanoparticles of LCs exhibit new and exciting phenomena compared to bulk liquid crystalline phases owing to the presence of unusually large number of molecules on the surface. Promising new techniques have been developed to controllably orient liquid crystalline nanostructures in the desired direction in device configurations.

It is understood that nanotechnology is hunting for simple and versatile bottom-up self-assembly-based processes to assemble and (re)organize molecules and/or nanoparticles into well-defined functional superstructures in multiple dimensions over multiple length scales for many advanced technological applications. LCs are emerging as the viable systems for the dynamic self-assembly of nanomaterials in LC media as well as molecular dynamic self-assembly of LC molecules themselves. For example, it has been demonstrated that LCs enable reconfigurable and switchable

self-assembly of dispersed nanoparticles directed by the nanoscale molecular ordering in these anisotropic fluids with a broad range of mesomorphic states. Furthermore, various nanostructured LC phases have been used as "templating" media for the preparation of anisotropic nanoparticles with tunable shape, size, and controllable polydispersity. Liquid crystalline nanostructures have also been employed for encapsulation and delivery of drugs. Processing nanomaterials through liquid crystalline phase yields high performance materials and devices, and LC noble metal nanoparticle superstructures are envisaged to furnish optical metamaterials. Thus, the focus of this book is on nanoscale phenomena of LCs and their manipulation, mutually beneficial properties of LCs and nanoparticles, and nanoscale control of self-assembly and self-organization of LCs toward efficient and enhanced device performances.

This book does not intend to exhaustively cover all the topics on nanoscience with LCs as it is extremely difficult to do so within a single book. Instead, the book focuses on the recent development of the most fascinating theme about nanoscience with LCs: from self-organized nanostructures to applications. The chapters span the following topics: holographic LCs for nanophotonics (Chap. 1), directing 3D topological defects in smectic LCs and their applications as an emerging class of building blocks (Chap. 2), liquid crystalline 1D and 2D carbon materials (Chap. 3), LC-gold nanoparticle hybrid materials (Chap. 4), photoresponsive chiral LC materials: from 1D helical superstructures to 3D periodic cubic lattices and beyond (Chap. 5), glassy LCs as self-organized films for robust optoelectronic devices (Chap. 6), directing self-organized columnar nanostructures of discotic LCs for device applications (Chap. 7), discotic liquid crystalline blends for nanostructure formation toward bulk heterojunction active layer in organic photovoltaics (Chap. 8), ion-based LCs: from well-defined self-organized nanostructures to applications (Chap. 9), nanotechnology and nanomaterials in photodeformable liquid crystalline polymers (Chap. 10), self-assembled liquid crystalline conjugated polymers: synthesis, development, and their advanced electro-optical properties (Chap. 11), and solubilization and delivery of drugs from GMO-based lyotropic liquid crystals (Chap. 12). In each chapter, the state of the art, along with future potentials in the respective fields is discussed and highlighted by the leading experts.

This book offers up-to-date and accessible coverage of nanoscience with LCs, with emphasis on self-organized nanostructures and their applications for undergraduate students and graduate students, as well as the researchers in both academia and industries in the fields of organic chemistry, polymer science, liquid crystals, materials science, material engineering, electrical engineering, chemical engineering, photonics, optoelectronics, nanotechnology, medicine, pharmacy, and renewable energy. I hope that readers will find this book professionally valuable and intellectually stimulating in the rapidly emerging area of nanoscience with liquid crystals.

Finally, I would like to express my gratitude to Claus Ascheron at Springer for inviting us to bring this exciting field of research to a wider audience, and to all our distinguished contributors for their dedicated efforts. I am indebted to my wife Changshu, my sons Daniel and Songqiao for their great support and affectionate encouragement.

Kent, December 2013 Quan Li

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