

PREFACE

Everyday we are exposed to a myriad of applications of polymer thin films. This is whether it occurs in food wrapping, the packaging of virtually any item that is sold, or in protective coatings placed on the surface of furniture or glass. More and more often, though, the thickness of the polymer film decreases to dimensions comparable to the dimensions of a single polymer chain, or in the case of block copolymers or mixtures, comparable to the characteristic period of the microphase separated or phase separated morphology. For example, in the case of microelectronic circuits where polymers can be used as a dielectric insulator or as a template to produce a porous oxide layer, the dimensions of and separation distance between the conducting elements is rapidly decreasing to several tens of nanometers. We are forced, therefore, to ask the question as to whether the confinement of the polymer to such small dimensions will change the fundamental characteristics of the polymer. In addition, with such small scale features, the surface to volume ratio increases significantly, so does the abundance of interfacial area affect the nature of the polymer in the confined geometry. In the case of block copolymers, how does such confinement alter the nature or orientation of the microphase-separated morphology? More importantly, if we can understand the influence of such confinement, can we use this to our advantage in designing systems to induce behavior not seen in the bulk or can we control the interactions of the polymer or block copolymer with the interfaces to manipulate the spatial arrangement of the nanoscopic elements in the morphology? If so, then this will open numerous applications of polymers and block copolymers in the burgeoning field of nanotechnology which encompasses applications ranging from ultrahigh density storage media, ultralow dielectric constant materials, high resolution separations media,

self-healing and self-corralling nanocomposites, flexible electronics and displays, and photovoltaic devices. Consequently, there has been a significant growth in the amount of research dedicated to understanding the structure and properties of polymer thin films.

The growth in the interest of polymer thin films has also been catalyzed by the increase in the number of techniques available to characterize thin polymer films. While these techniques may have been available for decades, only recently has it been recognized that they could be used to great advantage to characterize polymeric materials. Some of these techniques include scanning probe microscopies, neutron and x-ray reflectivity, grazing incidence x-ray scattering, forward recoil and Rutherford backscattering spectroscopies, dynamic secondary ion mass spectroscopy, x-ray microscopy and electron tomography. The growth in the use of these techniques to characterize polymer thin films, coupled with the use of fairly standard techniques, like ellipsometry, x-ray photoelectron spectroscopy, electron microscopy, x-ray and neutron scattering, dielectric spectroscopy, infrared and Raman spectroscopies, and optical microscopy, has revolutionized our understanding of polymer thin films. At the same time, there have been tremendous advances made in modifying either the chemical nature or the topography of surfaces, by use of photolithography, electron beam lithography, ion beam etching, and surface specific chemistries. This has imparted elegant routes to control the interactions between a polymer and a surface.

Perhaps the most significant development in the characterization of polymer thin films is the interest that a broad scientific community has taken in this area. From the engineering side, there are challenges that are faced in producing perfectly uniform thin films. Yet, this in turn has sparked the interest from the physics community in studies on instabilities in thin films and on the confinement of highly ordered structures. Controlling interfacial interactions has presented numerous challenges to surface chemists, both small molecule chemists and polymer chemists. The influence of confinement on phase transitions like crystallization, phase separation and microphase separation, has piqued the interest of physicists and physical chemists. Producing surfaces with well-defined topographies, chemistries and mechanical properties

has enabled the manipulation of the interactions of living cells with surfaces, and as such, has generated interest from the biological and microbiological communities. This convergence of interest from a wide-range of different disciplines has further promoted advances in our understanding of thin polymer films.

An overview encompassing the large variety of areas that have spun off from this vastly developing field is overdue. It is, however, important that this overview be understandable by the novice to the area and appreciated by the experts. This is the rather daunting task that faced the authors of the different chapters in this book. We hope that these chapters will serve as a useful resource for instructors of undergraduate and graduate courses. To reflect the interdisciplinarity, the authors of the different chapters include chemists, engineers, materials scientists and physicists that have made significant contributions in their respective areas.

This book contains eleven chapters that can be categorized into six major areas:

- The design and construction of nanostructures in block copolymer films — the fundamental principles, fabrication methods and applications (Ch. 1–4)
- Alternative methods of fabricating sophisticated nanostructures in polymer thin films (Ch. 5–6)
- Crystallization of polymers confined in nanometer films (Ch. 7)
- Tribology of polymer thin films — friction and adhesion (Ch. 8 and 9, respectively)
- Wetting stability of polymer films supported by a substrate (Ch. 10)
- Novel dynamical properties of polymer nanometer films (Ch. 11)

We are indebted to the contributors of this book who have abided to the cause and taken time and effort in completing the chapters. Despite the crash of a hard disk (Shimomura), laboratory floods (Jacobs) and over-commitment of time (all of the authors), the chapters were completed in a timely manner, are of high-quality, and a pleasure to read. We are grateful to the students and postdoctoral fellows in our groups (Z. Yang, J. Wang, R. Tangirala, W. Chen, J. Xu, J. Chen, D. Chen, L. Li,

P. Dobriyal, J. He and H. Liu) who had helped compile the subject index. Special thanks are due to the anonymous reviewers who had generously contributed their time in reading the chapters and given suggestions for improvements.

We hope that the students, professors and researchers will find this book a useful guide and resource to the field of polymer thin films.

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