Preface

The advancement of flexible electronics has spanned the past forty years ranging from the development of flexible solar cell arrays made from very thin single-crystal silicon to flexible organic light-emitting diode displays on plastic substrates. The recent rapid development of this field has been spurred by the continuing evolution of large-area electronics with applications in flat-panel displays, medical image sensors, and electronic paper. Many factors contribute to the allure of flexible electronics; they are typically more rugged, lighter, portable, and less expensive to manufacture compared to their rigid substrate counterparts. Demonstrations of flexible electronics promise the availability of robust, lightweight, and low-cost electronics in the near future and this book is arranged to give the reader a survey of the materials that are used to fabricate these devices on flexible media. Subsequent chapters are organized to provide an overview of the different applications that can be created with a wide variety of materials systems. The range of polymeric to inorganic materials encompasses a wide array of performance benchmarks. It is these benchmarks of device characteristics (both electrical and mechanical) and performance, and the processes involved to make the device that will ultimately determine the suitable applications. It is not the intent of this book to give an exhaustive review of the technology but rather to provide a starting reference for a wide array of materials and applications; the chapters presented are also intended to augment existing literature in the field of flexible electronics.

The materials, processes, and applications for flexible electronics cover many different areas and we begin the book with a general overview of the field and the evolution of the technology. The mechanical stability of thin films on foil substrates is an area of active study and the understanding of these characteristics needs to be developed in order to fabricate multilayer structures with minimum offset in layer-to-layer alignment (Chapter 2). A review of processing conventional inorganic thin-film materials at low temperatures is given in Chapter 3. The chapter provides an overview of the materials and device characteristics for low-temperature silicon-based thin-film dielectrics and semiconductors. Chapter 4 describes how the understanding of the mechanical stability of thin films on foil substrates and low-temperature processing of conventional inorganic materials, such as amorphous silicon (a-Si:H), can be used for integration onto low melting point plastic platforms. These semiconductor materials have already been optimized for flat panel display applications and the transition to flexible electronics enables integration with organic light emitters to create applications in flexible emissive displays. The transition metal oxides (TMO) have the potential for creating high-performance thin-film transistor (TFT) devices beyond the performance offered by a-Si:H or poly-silicon TFTs. Chapter 5 provides an overview of the TMOs and demonstrates a novel nano-imprint lithography approach that can be used to fabricate flexible backplanes in a roll-to-roll process. Applications towards large-area flexible image sensors are another active area of research. Chapter 6 reviews ink-jet patterning techniques for fabricating a-Si:H based x-ray image sensors for medical imaging applications and ink-jet patterning for all-additive processing of backplane arrays.

The development of organic and polymeric materials for flexible electronics is progressing at a rapid rate with organic semiconductor materials producing devices that rival the performance of conventional a-Si:H TFTs. Small molecule semiconductors such as pentacene have been used to make organic TFTs and have shown performance exceeding silicon-based TFTs. Chapter 7 discusses two applications, image sensing and micro-electro-mechanical systems (MEMS), where organic materials compete well with silicon-based devices in flexible applications. In Chapter 8, the impact of materials and device physics on device and circuit design is discussed in the context of specific applications (displays and radio-frequency identification tags) based on pentacene active layers.

The transition to solution processable materials provides a potentially limitless choice of flexible electronics applications and processes (Chapter 9). These materials offer low-cost processing capabilities from simple spin casting to jet printing for device fabrication. The major limitation of the materials system is its relatively low performance for TFT applications. As these materials continue to improve, the appeal of low fabrication cost is also a catalyst for using polymeric semiconductors in photovoltaic applications. A review of excitonic solar cell properties and characteristics is presented in Chapter 11 along with an assessment of the applications for low-cost large-area power sources based on polymeric "green" technologies (Chapter 12).

Nano-scale materials are also suitable for flexible electronic applications. The size scale and electrical characteristics of randomly oriented carbon nanotubes (CNTs) mats provide a material that is highly compliant, conductive, and transparent in the visible spectrum. These three attributes give CNTs an advantage for use as transparent conductors for applications in solar cells and flexible displays (Chapter 10). Finally, none of these materials will have much functionality if a suitable substrate is unavailable. Chapter 13 reviews the characteristics required for flexible platforms for use in electronic applications and the processes and barrier materials that are required in order to make the plastic films optimal for device applications.

Lastly, we would like to thank all the contributing authors for their time and effort in preparing the manuscripts presented in this book. It is the work of these people and all the scientist, researchers, and engineers in the field that make the technology of flexible electronics exciting and challenging. We are also grateful to the Palo Alto

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