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Editors

Liquid Crystalline Semiconductors

Materials, Properties and Applications

Springer

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Preface

This is an exciting stage in the development of organic electronics. No longer is it an area of purely ‘academic interest’ but increasingly real applications are being developed and some of these are beginning to come on-stream. There have been several drivers for the surge of interest shown by the electronics industry. Perhaps the greatest is the promise afforded by organic systems for low-cost processing, e.g., methods of fabrication such as roll-to-roll contact printing or ink-jet printing in which the components are ‘assembled’ on low-cost substrates at room temperature. The long-term vision is for the creation of integrated devices in which, for example, a photovoltaic cell, a sensor and a display, all made of organic materials, is printed onto a plastic film in a single operation. Another factor in the recent development of organic electronics is the huge advances made in organic synthesis over the last half century, which make it easy to fine-tune the properties of organics at a molecular level in a way that is simply not possible for their metallic and semi-metallic counterparts. Finally, organics are much easier to interface with biomaterials, which is perhaps the key problem in the development of new generation biosensors. Another consideration in the development of organic electronics has been ‘Green Issues’: not only the need to develop energy-efficient methods of manufacture but also the need to develop methods based on renewable (organic) rather than finite (inorganic and metallic) components.

Although it seems improbable that organics will ever compete with silicon-based devices in terms of high-end computing applications, where device speed is of the essence, there are many low-end areas of application, where we can look to see traditional inorganic components increasingly replaced by organics. Areas that have already been commercially developed or which are under intensive development include organic light emitting diodes (for flat panel displays and solid state lighting), organic photovoltaic cells, organic thin film transistors (for smart tags and flat panel displays) and sensors. Potentially this is a field that will affect every aspect of our lives and have an impact in every home and in every business.

Within the family of organic electronic materials, liquid crystals are relative newcomers. The first electronically conducting liquid crystals were only reported in 1988, but already a substantial literature has developed. The potential advantage of liquid crystalline semiconductors is that they have the easy processabilty of amorphous and polymeric semiconductors, but they usually have higher charge carrier mobilities. Their mobilities do not reach the levels seen in crystalline organics, but they circumvent all of the difficult issues of controlling crystal growth and morphology. Liquid crystals self-organise, they can be aligned by fields and surface forces and, because of their fluid nature, defects in liquid crystal structures readily self-heal.

Because this is a relatively young field, there are still issues which need to be understood. In particular, the theory of electronic conduction in liquid crystals is much less well developed than that of electronic conduction in other organic materials and, although the relationship between molecular structure and conductivity is mostly understood, some issues still remain to be resolved and understood.

With these matters in mind, this is an opportune moment to bring together a monograph on the subject of 'Liquid Crystalline Semiconductors'. The field is already too large to cover in a comprehensive manner, so our aim has been to bring together contributions from leading workers, which cover the main areas of the chemistry (synthesis and structure/function relationships), physics and potential applications. A general introduction to liquid crystals and the nature and kinds of their mesomorphic behaviour and structure (mesophases) is given in Chap. 1. A description of the nature and mechanisms of different kinds of charge transport in calamitic (nematic and smectic) liquid crystalline semiconductors is given in Chap. 2 followed by a similar treatment of columnar (discotic) liquid crystalline semiconductors in Chap. 3. The different approaches and methods of determining charge transport in liquid crystals are also described in detail. Chap. 4 provides a comprehensive description of the synthesis of a wide range of columnar liquid crystalline semiconductors. A series of reaction schemes are used to illustrate different synthetic strategies and approaches to the synthesis of this special type of liquid crystal. Chapter 5 gives an extensive discussion of the nature and magnitude of charge transport in reactive mesogens (monomers) and how they are determined. A similar treatment of the corresponding liquid crystal polymer networks is also given in this chapter. An insight into the nature and complexity of the optical properties of liquid crystals is provided in Chap. 6. Chapters 7, 8 and 9 describe the modes of operation, configuration and performance of a range of electrooptic devices, i.e., organic light-emitting diodes (OLEDs), especially with polarised emission, organic photovoltaics and organic field-effect transistors, incorporating the types of liquid crystalline semiconductors described in the preceding chapters. Our hope is that this book will provide a useful introduction to the field both for those in industry and for those in academia and that it will help to stimulate future developments.

Richard J. Bushby
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