book reviews

Adhesive Strength of Fibre–Polymer Systems

Yu. A. Gorbatkina
Ellis Horwood, Hemel Hempstead, 1992, 264 pages, £65.00
ISBN 0-13-005455-0

This book is a translation from the Russian and is based on work undertaken over the last two decades at the Reinforced Plastics Laboratory of the Institute of Chemical Physics of the USSR Academy of Sciences. It is entirely devoted to a study of the adhesive strength of the fibre–polymer interface and the majority of data has been obtained by the 'pull-out' technique. Most results are for adhesives and fibres used in Russia for fabricating composite materials but the aim is to present principles and relationships of general validity and a large number of results are for epoxy-based polymer composites.

The shear strength of fibre–polymer joints is usually measured on specially prepared samples of fibres embedded in an adhesive layer. Clearly joint geometry depends on the length of the layer of adhesive in contact with the fibre as well as on the fibre diameter and accurate data depend, amongst other things, on good contact and on uniformity. Techniques have been developed at the Reinforced Plastics Laboratory for ensuring reproducible and reliable specimen production in sufficient quantities to produce statistically significant results. These techniques are detailed in the opening chapter which characterizes the book as a whole by being extremely thorough and including a lot of experimental detail based on years of experience. This is followed by an equally detailed chapter on the statistical treatment of results and the calculation of adhesive strength for competing adhesive and cohesive modes of fracture. This is extremely mathematical and results in a procedure for separating the effects of cohesive and adhesive fracture together with an algorithm for treating the data. The algorithm itself (although admirably detailed compared with the sketchy outlines so often given) is of enormous complexity and runs to thirty-nine steps over five pages of the Appendix. Whilst this may form the basis of a computer program to treat experimental data systematically, it will not be entered into lightly by any but the most dedicated specialists.

Following these foundation chapters on experimental techniques and data analysis the book continues with a systematic presentation of the effects of various factors on adhesive strength. Scale effects and local adhesive strength as a measure of interfacial interactions are considered in Chapter 3, although any application of fracture mechanics is explicitly excluded, which seems rather unfortunate. This is then followed by a systematic consideration of the effects of curing conditions, test temperature and loading rates in Chapters 4 and 5, and the effects of binders and surface modification in Chapter 6. High-strength and high-modulus fibres are considered in Chapter 7. Only in Chapter 8 does the treatment widen out to consider the relationship of the strength of composite materials to the strength and properties of the fibre–matrix interface. Finally, in Chapter 9, the adhesive strength of fibre–thermoplastic polymer joints is considered.

Overall the book gives a very thorough treatment of its chosen topic — the adhesive strength of fibre–polymer systems — but the specialization of subject matter may well limit its appeal. It will be of value as a reference text to those embarking on research in the adhesive strength of composites and to those needing to know the effects of experimental variables on such measurements. The claim on the back cover that the book will be useful to 'all involved in the production and utilization of fibre composites' seems a little ambitious. However the proposed readership — those involved in surface phenomena, adhesion physics and the strength of composites — will find it a comprehensive treatment of an important topic.

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Polymers for Electronic and Photonic Applications

C. P. Wong (Ed.)
Academic Press, San Diego, 1993, 661 pages, £73.50
ISBN 0-12-762540-2

With the notable exception of one Japanese paper, all the other contributions to this text are of United States origin, though from a wide range of academic departments, manufacturing and user industries whose interests are embraced by its 'catch-all' title. The electronic and photonic applications of polymers are as diverse as the applications of wood in fabrication and construction, and it is this that inevitably lends the text the appearance of a collection of papers intended for selective reading. But, this is not a criticism, for whilst texts of a comparable size might be written on any one of the topics, this is an admirable compilation of information for anyone who is interested to delve into the structures and properties of the materials that underpin integrated circuit technology, without their being exhausted by the detail. The first chapter gives an overview of the subjects to be developed later and it makes ideal reading for the non-specialist. The subsequent chapters are comprehensively referenced with up-to-date papers and could well become essential reading for chemists, physicists and material scientists upon entry to one of the specialist areas.

For the last couple of decades we have seen the number of components on an integrated circuit chip, on average, double every 18 months. The objective of the book is to review and discuss the important applications of polymers that have facilitated this ongoing miniaturization of semiconductor, very large-scale integrated circuit (VLSI) devices, and which have also enabled the advent of optoelectronics. Typically, in the VLSI context, these are the polymers that are used in microlithograpy, as interlayer dielectrics, as passivating thin films and for electronic packaging and interconnects. In photonics they are the polymers with the potential for application as waveguides, as optical switches, and for data storage and retrieval.

In so far as it is possible to identify a natural order of presentation of the subject matter of the book, it has been achieved. The overview of the first chapter is followed by a paper devoted to the chemistry of resists for microlithography; this being the area that deals with the primary imaging of the circuit features of VLSI in a radiation-sensitive polymer, prior to the transfer of the pattern to an underlying substrate. These methods find use in the manipulation of other polymeric materials used in electronic devices, such as the polyimide and other resins that are used as interconnect dielectrics which are discussed in the next chapter. There follows a discussion of the processes of encapsulation, and the materials for use as encapsulants to protect integrated circuitry from an otherwise hostile environment. Polyimides and polyimide-siloxanes then get chapters of their own, even though they have featured regularly in the previous chapters. The justification

that is offered is in terms of the excellent electrical and thermal resistances offered by these materials, coupled with their adhesive properties, their ease of preparation, purification and processability, but difficulties that ensue from giving individual materials both separate and inclusive discussion are evident within these chapters. The particular scenes have to be set through repetition of some of the foregoing material. The same treatment is then meted out for epoxy resins prior to a switch to thermoplastic materials and polymers for increased circuit density in interconnection technology. Even though these chapters are free standing, restatements of methods described earlier are still to be found.

The shift away from the classical structure–property considerations associated with the polymers that meet the requirements of conventional electronic applications comes in the later chapters, the first of which is concerned with the behaviour of piezoelectric and pyroelectric polymers. Apart from selected fluoropolymers there are few others that display these properties and this chapter is devoted to the underlying physics. Likewise, the theory behind non-linear optical materials is developed in some detail before any discussion of the known polymer structures that exhibit these effects. The third-order non-linear effects are then singled out for special attention and repetition is again evident as the underlying theory unfolds. Here, there is so little specific mention of polymers that one is left with the distinct impression that a chapter written jointly with the author of the previous paper would have made a single, more satisfactory contribution.

If integration of the molecular science and the technology was a hallmark of all the earlier papers, the one concerned with polymers for optical waveguides is predominantly concerned with circuit structures and design implementation. Given that the technology is still in its youth, this is not surprising, but the chapter does not place polymers, their properties and their processing at the central position suggested by the book's title. This is not a comment that can be applied to the last two chapters which are, respectively, concerned with the Langmuir–Blodgett manipulation of electrically responsive polymers, and the basic concepts of the mechanical behaviour of polymers. However, it is difficult to understand why the last chapter has been placed where it is or, indeed, why it has even been included, unless it has been directed at readers with a background in electronic engineering. It has no direct relevance to the rest of the subject matter, and since the readers of the remainder of the book would have to be well versed in either polymer chemistry, polymer physics or materials science, they should already have a good measure of the understanding it conveys. Regrettably, this last chapter sticks out like a sore thumb and the author does little to put it into context.

The book is securely bound and will withstand years of handling. Published only in hardback, and selling in the United Kingdom at £73.50, it will be purchased by libraries but not individuals. It would nonetheless be a useful reference to have to hand within any university, industrial or government research centres that are concerned with such applications of polymers. It is not going to feed the requirement of day-by-day research, but with its well produced figures and diagrams it will fulfil a useful introductory purpose, and properly place the research in a wider technological context.

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Polymer Chemistry: An Introduction (3rd Edn)

Raymond B. Seymour and Charles E. Carraher (Eds)
Marcel Dekker Inc., New York, 1992, 664 pages, $55.00
ISBN 0-8247-8719-6

This textbook provides an easily readable introduction and essential guidance to the field of macromolecular chemistry for graduate or final year undergraduate students; it also presents the practitioner and technologist with a general review of the subject. There is sufficient material relating to polymer characterization, structure–property relationships, and polymer processing to give a broad overview of the field. This edition covers new topics such as superconductors, enzymes, comparative/synthetic macromolecular structures, geotextiles, solid waste, room temperature vulcanizing agents, polymer degradation and kinetics of biopolymer catalysis.

After a brief note on nomenclature, this book contains 17 chapters, covering a very wide range of topics in polymer chemistry. The text starts with an introduction to polymer science in order to give a general idea about the subject. Chapter 2 covers polymer structure (morphology), including the stereochemistry of polymers and molecular introductions. Both of these subjects have been described very clearly and some problems, useful for students, are also mentioned. The third chapter describes the rheology and solubility of polymers and how the interaction between rheology and thermodynamics is crucial for a complete understanding of the properties of blended polymers. Chapters 4 and 5 are concerned with molecular weight determinations and the areas of physical testing and characterization of polymers with the aid of spectroscopy and thermal analysis techniques. Chapter 6 covers an understanding of natural polymers which is the most rapidly growing area of macromolecules, i.e. DNA, RNA, proteins and polycarbohydrates. Chapters 7–10 deal with the mechanisms and chemical aspects of polymerization reactions, i.e. ionic and complex coordinative polymerization, free-radical chain polymerization and copolymerization. These chapters are well supported by up-to-date and useful examples. Chapters 11 and 12 are concerned with the chemistry and the sources of inorganic polymers containing organic portions which are called inorganic–organic polymers and inorganic polymers such as alkaline silicate glass. Chapters 13 and 14 are brief introductions to the areas of fillers and reinforcements of polymers and also plasticizers, stabilizers, flame retardants and other additives.

This book also contains two useful chapters, Chapters 15 and 16, dealing with chemical reactions of polymers and the synthesis of reactants and intermediates. Again the authors have provided good coverage and clear descriptions of the chemical reactions involved. The final chapter, Chapter 17, gives a brief description of the techniques in polymer technology. In this chapter the reader finds a list of many American companies divided according to their function which are active in the general area of synthetic polymers.

This book also contains useful appendices with the trade names of polymers, structures of common polymers and mathematical values and units. There are numerous useful exercises in most of the chapters with solutions at the end of the book. Overall, this book contains much of value and I recommend it to students seeking knowledge of the basic principles of polymer chemistry and I think it should be in the library of any research group interested in macromolecular science.

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Thermotropic Liquid Crystal Polymer Blends

F. P. La Mantia (Ed.)
Technomic Publishing Co., Basel, 1993, 187 pages, $65.00
ISBN 0-87762-960-9

I was encouraged by the title of this book: blends of liquid crystalline polymers may still prove to be commercially viable despite the downturn in activity amongst many companies, yet I was not aware of