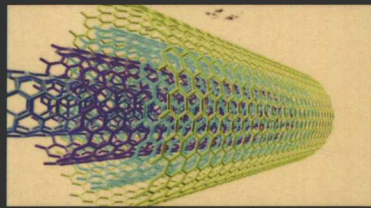
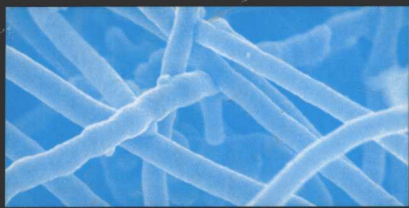
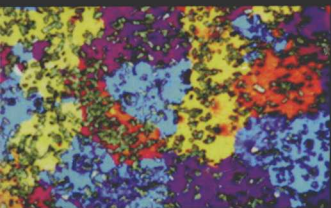


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OF

COMPOSITES

SECOND EDITION

LUIGI NICOLAIS
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VOLUME 1

WILEY ENCYCLOPEDIA OF COMPOSITES

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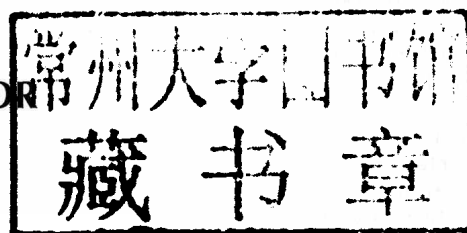
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SECOND EDITION

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PREFACE

The development of composite materials and related design and manufacturing technologies is having a strong impact in the history of materials. Although composite materials had been known in various forms throughout the history of mankind, the introduction of modern composites probably began in 1930 with the use of fiberglass and the availability of epoxies resins. The pace of composites development, already fast, was accelerated during World War II and in the late 1940s, when the use of composites for structural and semistructural parts and innovative manufacturing methods such as filament winding, spray-up, pultrusion, and vacuum bag molding were being explored and then adopted. The introduction of new fibers, such as carbon, aramid, and fibers made from ultra high molecular weight polyethylene, and the development of improved resins contributed to the further expansion of the composites market which at the beginning of the 1990s was so widespread. In this time frame, the first edition of *Encyclopedia of Composites* was edited by Stuart M. Lee and published in 1991 by John Wiley and Sons. The encyclopedia represented an exhaustive reference source, covering most of the topics in the field of composite science and technology.

Many years have passed since publication of the first edition; research involving composite materials has rapidly advanced and today, composites represent a 20 billion dollar industry. This second edition of the *Encyclopedia of Composites* reflects many of those changes including information on contemporary composite processing technologies, recent advances in composite materials such as nanocomposites and smart composites, and the growth of new application fields (biomedical, electronic, advanced construction applications, nanotechnologies, etc). New articles cover the topics of nanomaterials and related technologies as well as the development of novel polymeric matrices from renewable resources for bio-based composites, both of which are expected to grow rapidly and significantly in the next decades. Particular

attention is given to the evolution of composites from structural to functional in order to design innovative devices (such as light-emitting diodes, chemical and biological sensors, and polymer electronic circuits). The introduction of innovative materials and their use in novel applications implies developments in methodology and process technologies are widely discussed in several articles.

The content of the Encyclopedia of Composites has expanded upon the foundations laid within its first edition and the number of entries has been extended up to 258. Articles have been revised and expanded, while those covering outdated topics have been deleted. More than 50 new articles have been introduced to provide current information on the most recently developed areas.

All chapters have been written by authors belonging to more than thirty different countries, and who have been selected from international universities, industries, and research institutions. Each article has been subjected to a peer review and editorial processing. All referees have contributed to the improvement, clarity, and comprehensiveness of the articles, and they are all recognized international experts in the field. The entries are presented in alphabetical order, with each article including a list of references for further reading; most of the articles contain tables and figures. This edition of the encyclopedia has been published in print and online versions; abstracts and keyword searching are features that have been added in the latter. This achievement could not have been possible without the contribution of several people. First of all, we would like to thank the authors and the referees who have reviewed each article, providing much constructive criticism. Moreover, our thanks are due to the Associate Editors for their efforts and continuous support given during the preparation of the encyclopedia; and finally, to Senior Editor Anita Lekhwani and Editorial Assistant Catherine Odal, and all the staff from Wiley for their fundamental support.

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