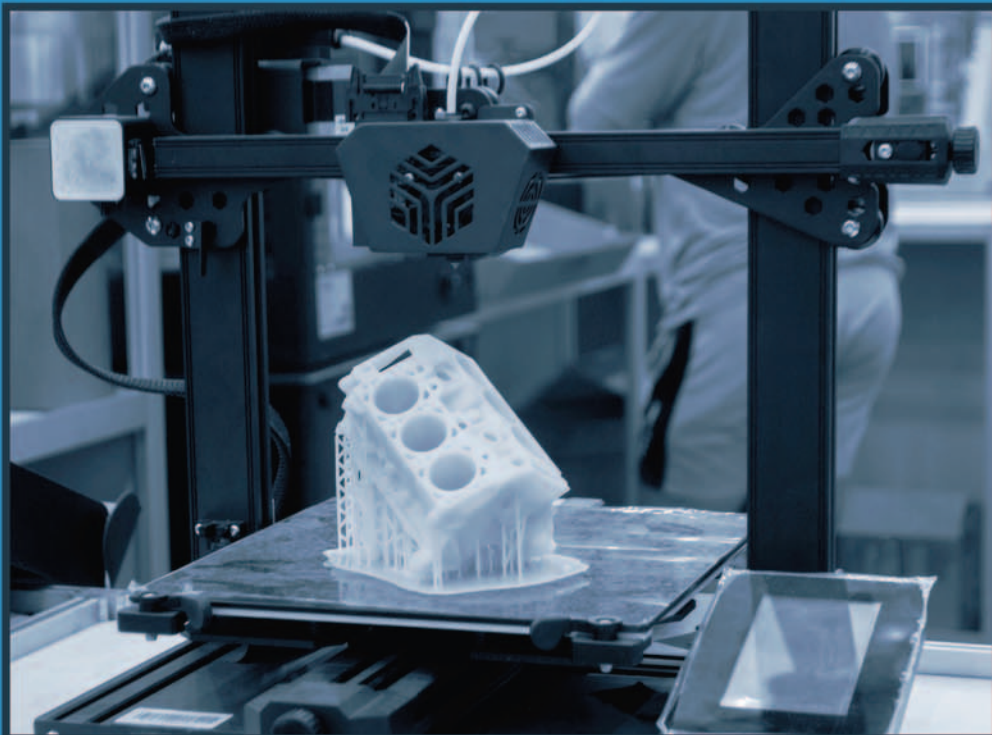


WOODHEAD PUBLISHING IN MATERIALS



ADDITIVE MANUFACTURING OF POLYMER COMPOSITES

**MATERIALS PROCESSING, STRUCTURAL
DESIGNS AND APPLICATIONS**



Edited by
YASIR BEERAN POTTATHARA
HANUMA REDDY TIYYAGURA
KALIM DESHMUKH

Additive Manufacturing of Polymer Composites

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Woodhead Publishing in Materials

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Materials Processing, Structural Designs
and Applications

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3D-printed polymer composites for electrochemical energy storage

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18.1 Introduction

Nanocomposites are advanced hybrid materials formed by incorporating nanoscale fillers into a bulk host matrix, most commonly polymers, ceramics, or metals. The defining characteristic of nanocomposites is that the fillers possess at least one dimension below 100 nm, giving them exceptionally high surface-to-volume ratios and unique physical, chemical, and electronic properties (Bae et al., 2010). Even when incorporated at relatively low concentrations, these fillers can impart remarkable improvements in mechanical strength, electrical and thermal conductivity, chemical resistance, and biocompatibility compared with the pristine host material. This distinctive ability arises from nanoscale interactions and the formation of percolation pathways, through which electrical or thermal transport becomes highly efficient.

Over the last 2 decades, nanocomposites have gained increasing attention across diverse industries such as aerospace, automotive, electronics, energy storage, sporting goods, and biomedical engineering. Some of the most extensively studied nanomaterials include carbon nanotubes (CNTs), nanowires, buckyballs, graphene, metal nanoparticles, and quantum dots. Each offers distinct advantages: CNTs and graphene provide outstanding mechanical strength and electrical conductivity, while metallic nanoparticles (NPs) contribute to catalytic activity and improved thermal transport. However, despite these advantages, key challenges such as nanoparticle aggregation, poor dispersion, interfacial incompatibility with the host matrix, and increased processing costs continue to hinder large-scale commercialization (Farahani et al., 2012, 2016; Guo et al., 2015; Karageorgiou & Kaplan, 2005). Parallel to the growth of nanocomposites, additive manufacturing (AM), commonly referred to as 3D printing, has emerged as one of the most disruptive technologies in modern manufacturing (Ambrosi & Pumera, 2016). 3D printing technology is helpful in a wide variety of scientific fields due to its advantages, such as high speed, low cost, and the ability to fabricate complicated structures (Haider et al., 2020; Tahir et al., 2020; Yang et al., 2020; Zhu et al., 2020). Unlike conventional subtractive techniques, where material is removed to obtain the desired shape, AM builds components in a layer-by-layer manner from digital CAD models, offering unparalleled design freedom, reduced

Additive Manufacturing of Polymer Composites: Materials Processing, Structural Designs and Applications presents the latest developments in this technological field. The book focuses specifically on polymer composites used in additive manufacturing. It offers a detailed exploration of materials and their properties, and their specialized applications such as electrically conductive, metal-polymer, and shape memory polymer composites. The book discusses the basic principles of the manufacturing processes, material selection, and structural design. Furthermore, it covers the latest advancements in surface engineering, posttreatment processes, and the use of these materials in various industrial sectors. The book will be a valuable reference resource that will equip the researchers with key knowledge on the latest research trends, commercialization prospects, and environmental impacts of these additively manufactured materials and their applications across various industries.

Key Features

- Provides foundational and advanced-level knowledge on additive manufacturing processes specific to polymer composites
- Offers a unique compilation of different materials, including polymers, metals, and ceramics
- Emphasizes the mechanical, thermal, and electrical properties of 3D printed composites
- Covers wearable sensors, photocatalytic, automotive and aerospace, energy storage, biomedical, electronic, EMI shielding, and soft robotic applications
- Includes field-assisted manufacturing, computational modeling, and machine learning

About the Editors

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