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NANOTUBE SUPERFIBER MATERIALS

Changing Engineering Design

Nanotube Superfiber Materials Chapter 1 Introduction To Fiber Materials Micro And Nano Technologies

Steven D. Keller, Amir I. Zaghloul



Nanotube Superfiber Materials Chapter 1 Introduction To Fiber Materials Micro And Nano Technologies:

Nanotube Superfiber Materials Stephen C. Hawkins, 2013-09-16 The nature of fiber materials and the differences between conventional fibers and nanoscale fibers are discussed in this chapter The challenge of carbon nanotube CNT yarn fiber fabrication is provided from the perspective of conventional yarn fiber fabrication Prospects for large scale manufacturing and the physical properties of yarn are also discussed This chapter sets the stage for presentation of a compendium of techniques working toward producing superfiber materials **Advanced Processing and Manufacturing**

Technologies for Nanostructured and Multifunctional Materials II, Volume 36, Issue 6 Tatsuki Ohji, Mrityunjay Singh, Michael Halbig, 2016-01-05 The Ceramic Engineering and Science Proceeding has been published by The American Ceramic Society since 1980 This series contains a collection of papers dealing with issues in both traditional ceramics i e glass whitewares refractories and porcelain enamel and advanced ceramics Topics covered in the area of advanced ceramic include bioceramics nanomaterials composites solid oxide fuel cells mechanical properties and structural design advanced ceramic coatings ceramic armor porous ceramics and more *Nanotube Superfiber Materials* Mark Schulz, Vesselin

Shanov, Zhangzhang Yin, Marc Cahay, 2019-03-12 *Nanotube Superfiber Materials* Science Manufacturing Commercialization Second Edition helps engineers and entrepreneurs understand the science behind the unique properties of nanotube fiber materials how to efficiency and safely produce them and how to transition them into commercial products Each chapter gives an account of the basic science manufacturing properties and commercial potential of a specific nanotube material form and its application New discoveries and technologies are explained along with experiences in handing off the improved materials to industry This book spans nano science nano manufacturing and the commercialization of nanotube superfiber materials As such it opens up the vast commercial potential of nanotube superfiber materials Applications for nanotube superfiber materials cut across most of the fields of engineering including spacecraft automobiles drones hyperloop tracks water and air filters infrastructure wind energy composites and medicine where nanotube materials enable development of tiny machines that can work inside our bodies to diagnose and treat disease Provides up to date information on the applications of nanotube fiber materials Explores both the manufacturing and commercialization of nanotube superfibers Sets out the processes for producing macro scale materials from carbon nanotubes Describes the unique properties of these materials **Nanotube**

Superfiber Materials Mark Schulz, Vesselin Shanov, Zhangzhang Yin, 2013-09-16 *Nanotube Superfiber Materials* refers to different forms of macroscale materials with unique properties constructed from carbon nanotubes These materials include nanotube arrays ribbons scrolls yarn braid and sheets Nanotube materials are in the early stage of development and this is the first dedicated book on the subject Transitioning from molecules to materials is a breakthrough that will positively impact almost all industries and areas of society Key properties of superfiber materials are high flexibility and fatigue resistance high energy absorption high strength good electrical conductivity high maximum current density reduced skin and proximity

effects high thermal conductivity lightweight good field emission piezoresistive magnetoresistive thermoelectric and other properties These properties will open up the door to dozens of applications including replacing copper wire for power conduction EMI shielding coax cable carbon biofiber bullet proof vests impact resistant glass wearable antennas biomedical microdevices biosensors self sensing composites supercapacitors superinductors hybrid superconductor reinforced elastomers nerve scaffolding energy storage and many others The scope of the book covers three main areas Part I Processing Part II Properties and Part III Applications Processing involves nanotube synthesis and macro scale material formation methods Properties covers the mechanical electrical chemical and other properties of nanotubes and macroscale materials Different approaches to growing high quality long nanotubes and spinning the nanotubes into yarn are explained in detail The best ideas are collected from all around the world including commercial approaches Applications of nanotube superfiber cover a huge field and provides a broad survey of uses The book gives a broad overview starting from bioelectronics to carbon industrial machines First book to explore the production and applications of macro scale materials made from nano scale particles Sets out the processes for producing macro scale materials from carbon nanotubes and describes the unique properties of these materials Potential applications for CNT fiber yarn include replacing copper wire for power conduction EMI shielding coax cable carbon biofiber bullet proof vests impact resistant glass wearable antennas biomedical microdevices biosensors self sensing composites supercapacitors superinductors hybrid superconductor reinforced elastomers nerve scaffolding energy storage and many others

Nanotube Superfiber Materials Miao Zhu, Hongwei Zhu, 2013-09-16 Carbon nanotube CNT yarn represents one of the most remarkable macrostructures of CNT with its excellent performance in terms of mechanical and electrical properties Various synthesis methods have been developed and an increasing number of applications have been reported to date making yarn production one of the most active fields in current research on nanomaterials In this chapter we focus on the direct synthesis of long CNT yarns by chemical vapor deposition including some discussions of the growth parameters and key characteristics of as grown yarns A general introduction to the potential applications of CNT yarns fibers is given to outline its broad prospects in different fields

Nanotube Superfiber Materials Carla L. Lake, Patrick D. Lake, 2013-09-16 Carbon nanofibers are useful additives for improving the performance of polymer matrix composites but the performance has sometimes been hindered by limits encountered in composite processing Historically incorporating nanofibers and other nanoparticles into structural composites has required lengthy predispersion steps using specialty dispersion techniques Also filtration of the nanoparticles by larger reinforcements is a problem in resin transfer molding processes A way to overcome the problems with nanoparticles is through the use of carbon nanofiber sheets The sheet material eliminates predispersion and reagglomeration and allows nanoparticle insertion into prepreg materials in the same manner as with traditional reinforcement materials Composites fabricated with carbon nanofiber sheets demonstrate multifunctional property enhancements without altering

traditional composite manufacturing processes This chapter discusses development of carbon nanofiber continuous sheet goods and their applications

Nanotube Superfiber Materials Weifeng Li,Brad Ruff,John Yin,Rajiv Venkatasubramanian,David Mast,Anshuman Sowani,Arvind Krishnaswamy,Vesselin Shanov,Noe Alvarez,Rachit Malik,Mark Haase,Madhura Patwardhan,Mark Schulz,Sergey Yarmolenko,Svitlana Fialkova,Salil Desai,Ge Li,2013-09-16 Medical change is coming Robots and tiny machines built using nanoscale materials are going to fundamentally change engineering at the microscale and medicine will be the first area to benefit In tiny machine design copper and iron are replaced with carbon nanotube superfiber wire and magnetic nanocomposite materials Because of the small size of tiny machines high magnetic fields can be generated and high force high speed devices can be built Tiny machines are still in the early stages of being built and this chapter describes their engineering design and the work underway to build them The tiny machines will operate inside the body and detect disease at an early stage then provide precise therapy or surgery There will also be engineering applications for the tiny machines such as performing high throughput manufacturing operations at the microscale The design principles and materials processing techniques described herein will facilitate the development of nanomaterial robots and tiny machines for myriad applications ranging from miniaturized sensors actuators energy harvesting devices high performance electric motors and energy storage devices to smart structures with built in artificial responsive behavior

Nanotube Superfiber Materials Mark J. Schulz,Brad Ruff,Aaron Johnson,Kumar Vemaganti,Weifeng Li,Murali M. Sundaram,Guangfeng Hou,Arvind Krishnaswamy,Ge Li,Svitlana Fialkova,Sergey Yarmolenko,Anli Wang,Yijun Liu,James Sullivan,Noe Alvarez,Vesselin Shanov,Sarah Pixley,2013-09-16 Nanotubes are a unique class of materials because their properties depend not only on their composition but also on their geometry The diameter number of walls length chirality van der Waals forces and quality all affect the properties and performance of nanotubes This dependence on geometry is what makes scaling up nanotubes to form bulk material so challenging Nanotubes are also unusual because they stick together to form bundles or strands Nanotube superfiber materials are fibrous assemblages of nanotubes and strands The hope and dream of researchers around the world is that nanotube superfiber materials will have broad applications and change engineering design This chapter gives a perspective on nanotube superfiber development This chapter discusses new applications where we think we can go with the material properties and what applications will be enabled and new techniques for developing superfiber material

Nanotube Superfiber Materials T. Filleter,A.M. Beese,M.R. Roenbeck,X. Wei,H.D. Espinosa,2013-09-16 Performance and efficiency demands in industrial applications are pushing a need for carbon fibers that can outperform existing technologies Fibers that incorporate carbon nanotubes CNTs to enhance specific mechanical properties are a promising route to addressing this need Some of the major roadblocks to unlocking the full potential of macroscopic fibers based on CNTs are controlling and optimizing the shear interactions within and between CNTs geometrical organization of the CNTs and structural properties of the individual CNTs Several approaches have been

pursued in order to optimize the mechanical behavior of CNT fibers including irradiation induced covalent cross linking reformable or rehealable bonding and optimized geometrical and structural fiber designs These approaches are inspired by nature which uses hierarchical bonding schemes in optimized orientations to tailor the mechanical properties of its materials to the needs and environment of specific organisms In this chapter these approaches for developing high performance CNT fibers will be reviewed and an outlook of their potential impact will be discussed **Nanotube Superfiber Materials**

Simon Jestin,Philippe Poulin,2013-09-16 Recent developments in the field of carbon nanotube CNT based wet spun fibers are described in this chapter Wet spinning essentially enables a wide variety of polymers to be spun into fibers It has been used to produce composite fibers composed of polymers loaded with CNTs and even fibers solely composed of CNTs Fibers obtained by wet spinning approaches contain highly aligned CNTs making the fibers suitable for use in a variety of textile cable and composite applications Exciting results have been achieved at the laboratory scale Today it is critical to consider scale up of production of such superfibers so that applications can be fully validated **Nanotube Superfiber Materials**

Rachit Malik,Noe Alvarez,Mark Haase,Brad Ruff,Yi Song,Bolaji Suberu,Duke Shereen,David Mast,Andrew Gilpin,Mark Schulz,Vesselin Shanov,2013-09-16 Individual carbon nanotubes CNTs have exceptional mechanical and electrical properties However the transfer of these extraordinary qualities into CNT products without compromising performance remains a challenge This chapter presents an overview of the manufacturing of CNT sheets and buckypaper and also describes research performed at the University of Cincinnati in this field CNT arrays were grown using the chemical vapor deposition method Sheets were drawn from the spinnable CNT arrays and characterized using scanning electron microscopy to show the highly unidirectional alignment of the nanotubes in the sheet The anisotropic morphology of the sheet provides superior properties along one material axis as observed by measuring the tensile strength electrical resistivity optical transmittance and electromagnetic interference shielding properties of the material Surface modification of aligned multiwall nanotube sheets was carried out via incorporation of an atmospheric pressure plasma jet in the sheet posttreatment process Helium oxygen plasma was utilized to produce carboxyl COO functionality on the surface of the nanotubes X ray photoelectron spectroscopy confirmed the presence of the functional groups on the nanotube surface The sheet was further characterized using Raman spectroscopy Fourier transform infrared spectroscopy and contact angle testing Composite laminates made from functionalized CNT sheets showed higher strength than those made with pristine sheets The effects of plasma power and oxygen concentration were studied in order to determine the best possible parameters for functionalization Plasma treatment is a useful tool for fast clean and dry functionalization of CNTs This study demonstrates the ease of incorporating the plasma tool in the manufacturing process of sheets leading to the production of CNT polymer composites Macroscopic structures of nanotubes such as threads and sheets are leading to novel applications **Nanotube Superfiber Materials** Ana Laura Elías,Néstor Perea-López,Lakshmy Pulickal Rajukumar,Amber McCreary,Florentino López-Urías,Humberto

Terrones, Mauricio Terrones, 2013-09-16 Carbon nanotubes CNTs are considered one dimensional systems that possess fascinating electronic chemical and mechanical properties They exhibit metallic or semiconducting behavior depending on the nanotube diameter and chirality and they are ultrarobust and lightweight Moreover their surface can be chemically activated thus being able to establish different types of bonds between the carbon nanotube surface and a large number of chemical species for instance they could be introduced into a polymeric matrix improving its mechanical or electronic properties In addition CNTs are able to host different species in their hollow core such as ferromagnetic clusters molecules and gases Nowadays synthesis techniques have achieved control of the length and diameter of CNTs which constitutes a step forward toward applications In this chapter we address the issue of using CNTs as fundamental building blocks for constructing three dimensional 3D networks Here we present a review of the experimental and theoretical investigations on the formation of 3D networks using CNTs as the main component In addition the latest advances on the synthesis and characterization of different carbon nanostructures involving CNTs such as branches junctions and foams are discussed

Nanotube Superfiber Materials Michael B. Jakubinek, 2013-09-16 Individual carbon nanotubes CNTs have been reported to have the highest thermal conductivities of any known material However significant variability exists both for the reported thermal conductivities of individual CNTs and the thermal conductivities measured for macroscopic CNT assemblies e g CNT films buckypapers arrays and fibers which range from comparable to metals to aerogel like This chapter reviews the current status of the field summarizing a wide selection of experimental results and drawing conclusions regarding present limitations of the thermal conductivity of CNT assemblies and opportunities for improvement of the performance of nanotube superfiber materials

Nanotube Superfiber Materials Rufan Zhang, Yingying Zhang, Fei Wei, 2013-09-16 Ultralong carbon nanotubes CNTs are ideal building blocks for nanodevices and superstrong fibers Due to their high aspect ratio structure formed from sp² hybrid C C bonds they have extraordinary mechanical electrical and thermal properties It is of great importance to synthesize ultralong CNTs with controlled structures as well as optimized properties for their applications This chapter discusses the synthesis methods growth mechanisms structures electrical and mechanical properties as well as the applications of ultralong CNTs We show that the controlled synthesis of ultralong CNTs with certain structures and properties is of fundamental importance for their applications Finally we also show that the mechanical properties of ultralong CNTs are near the theoretical value showing great potential for their applications in superstrong fibers

Nanotube Superfiber Materials Steven D. Keller, Amir I. Zaghloul, 2013-09-16 The application of carbon nanotube CNT materials to produce lightweight flexible and durable RF antenna designs is explored through simulation fabrication and measurement of a variety of CNT thread and sheet antenna designs The conductivity and current distribution for a dipole antenna constructed from CNT thread rope are simulated using Hallén's integral equation for a thin wire applied to the Method of Moments An aperture coupled patch antenna composed of CNT sheet material is fabricated measured and

compared with a standard copper patch antenna Finally a meshed patch antenna composed of interwoven CNT threads is developed and simulated as a concept for a multifunctional communications antenna and reactive gas sensor **Nanotube Superfiber Materials** Nicola Pugno,2013-09-16 In this chapter the mechanics of nanotubes graphene and related fibers are reviewed with an eye to the limiting case of the design of a space elevator megacable The effect on the fracture strength of thermodynamically unavoidable atomistic defects with different sizes and shapes is quantified Brittle fracture is investigated both numerically with ad hoc hierarchical simulations and theoretically with quantized fracture theories for nanotubes graphene and related bundles **Nanotube Superfiber Materials** N. Govindaraju,R.N. Singh,2013-09-16 Nanostructured materials such as nanotubes exhibit properties significantly different from their bulk counterparts The effect of the length scale on nanostructure material properties in general is briefly discussed Boron nitride nanotubes BNNTs are wide bandgap Bandgap 5 eV semiconductor materials with attractive electrical optical mechanical and thermal properties The structure of BNNTs is delineated followed by a description of their main methods of synthesis Electrical mechanical optical and thermal properties of BNNTs are discussed and contrasted with those of the carbon nanotubes CNTs It is shown that the properties of BNNTs rival if not exceed CNTs in several areas It is envisaged that with further research BNNTs will find applications in nanoelectromechanical systems as ultraviolet light sources in composite materials and for storing gases **Nanotube Superfiber Materials** Lakshman K. Randeniya,2013-09-16 This chapter discusses fabrication of carbon nanotube yarn and coating of metals and nonmetals onto the yarn to increase electrical conductivity An increase in weight due to the metal particle coating is the trade off for achieving increased electrical conductivity Electrical conductors made from the hybrid alloy yarn may have multiple applications including in electrical conductors and transmission lines Carbon nanotube yarns also show potential as microelectrodes and robust and flexible chemiresistors for molecular detection The decoration of metal nanoclusters on the yarn provides high sensitivity and selectivity to gases that are present in industrial and environmental emissions Overall coating yarn with particles produces a multifunctional material that opens up new design possibilities for applications **Nanotube Superfiber Materials** Canh-Dung Tran,2013-09-16 Carbon nanotube CNT yarn a macroscopic structure of CNTs with many potential applications has attracted increased attention around the world and across many research areas and industrial fields including materials science electronics medical biology and ecology Spinning CNTs into yarn based on traditional textile spinning principles has demonstrated the potential in many important applications by producing weavable multifunctionalized yarns Between 1991 and 2010 new manufacturing methods have enabled the production of pure CNT yarns and CNT based composite yarns called superfiber suitable for weaving knitting and braiding with continuous improvements Especially various novel technologies are used to recently produce yarns for electrochemical devices and medical bioengineering Thus the studies on assembling individual CNTs into macrostructures of controlled and oriented configurations continue to play an important role in exploiting CNT potential applications

Nanotube Superfiber Materials Janet Hurst, 2013-09-16 This chapter describes the development of noncarbon nanotubes and compares the features of carbon and noncarbon nanotubes Carbon nanotubes are the most widely available nanotube material and are typically used for reinforcement of polymeric and glass materials electronic applications etc Noncarbon nanotubes such as boron nitride and silicon carbide have advantages for use in aggressive environments Possible uses of noncarbon nanotubes include reinforcement of metals polymers and glasses environmental and thermal barrier coatings electronics and radiation shielding

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