CARBON MATERIALS AND MANUFACTURING

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IIT Mandi

PRE-REQUISITES : Material Science for Engineers -OR- Structure of Materials (any basic material science course with description of crystal systems taught at UG level)
INTENDED AUDIENCE : Advanced B.Tech./ M.Tech. M.E./ Ph.D. from materials/ manufacturing/ energy sciences
INDUSTRIES APPLICABLE TO : This course is of high industrial relevance. All companies manufacturing carbon-fiber composites, as well as other carbon materials will benefit.

COURSE OUTLINE :

This course is focused on the preparation and structure-property relationship of various carbon materials for the purpose of device manufacturing. The contents are designed in a such a way that each type of carbon is taught in a material-manufacturing pair. Topics pertaining to the properties of various carbon allotropes, crystallinity and hybridization, raw materials, carbon fibers and composites, carbon nanomaterials and bulk industrial carbons will be covered.

ABOUT INSTRUCTOR :

Prof. Swati Sharma is currently an Assistant Professor in the School of Engineering at the Indian Institute of Technology (IIT), Mandi, India. Prior to this, she worked as a scientist at the Karlsruhe Institute of Technology and the University of Freiburg, Germany. She obtained her M.S./ Ph.D. from the University of California, Irvine, USA in 2013 in the field of carbon-based miniaturized sensors. She completed her Bachelors degree in chemical engineering from the Birla Institute of Technology and Science, Pilani, India, and worked a research scientist at the Ranbaxy Research Laboratories. Her primary research area is carbon-based devices, including biosensors, flexible electronics and bioelectronic medicine. She has expanded her research to industrial carbon manufacturing and obtaining high-value device friendly carbon materials from the urban solid waste. Her research work has been published in various peer-reviewed journals and books. She currently teaches various materials, manufacturing and energy systems related courses at IIT Mandi.

COURSE PLAN :

Week 1: Introduction to materials and manufacturing, mathematical representation of material properties, introduction to carbon, carbon on the Earth and in outer space, carbon in technology and economy, carbon isotopes, carbon atomic structure and hybridization
Week 2: Diamond, graphite, carbyne and curved carbons, classification of carbon allotropes, conversion of one allotropic form into another, phase diagram of carbon
Week 3: Engineering carbons, graphite crystal structure, stacking faults and rhombohedral graphite, graphite ore processing, synthetic graphite production from needle coke
Week 4: Kish graphite, polymer-derived graphite, Highly Oriented Pyrolytic Graphite (HOPG), pyrolysis of gaseous hydrocarbons, kinetics of graphitization, polymer-derived carbon: coking and charring mechanism
Week 5: Microstructure of non-graphitizing carbon, glass-like carbon: introduction, properties and industrial manufacturing, pyrolysis of polymers and other solid hydrocarbons, microfabrication with glass-like carbon
Week 6: Photolithography, X-Ray and Nano-Imprint Lithography, conversion of microfabricated structure into carbon, activated carbon: introduction, properties and industrial manufacturing
Week 7: Carbon black: introduction, properties and industrial manufacturing, carbon fiber: introduction and properties, melt spinning of petroleum pitches, electrospinning and viscoelasticity
Week 8: Carbonization of polyacrylonitrile (PAN) fibers, mechanical property testing methods for carbon fibers, defects in carbon fibers, Carbon Fiber Reinforced Plastic (CFRP), machining of CFRPs
Week 9: Carbon/ carbon, carbon/ metal and carbon/ concrete composites: Manufacture and Properties, graphene: introduction and crystal structure, graphene history and nomenclature, Chemical Vapor Deposition (CVD) of graphene
Week 10: Graphene CVD parameter optimization, defects in graphene, (n,m) notations, carbon nanotube: introduction and properties, vapor phase growth of carbon nanotube
Week 11: Vapor deposited diamond, diamond-like carbon, X-Ray Diffraction analysis of carbon, Raman spectroscopy of carbon, Transmission Electron Microscopy of carbon
Week 12: Gas adsorption isotherms and surface area analysis of porous carbons, numerical problem solving, large-scale industrial applications of carbon materials, micro and nano-scale applications of carbon materials, rigid and flexible carbon devices, device characteristics and challenges, supply chain of industrial carbons, summary and overview