ABSTRACT

In aerospace industry, “Unobtainium” is a relative term typically referring to a yet-to-be-developed light weight material with high mechanical performance, which can withstand extreme conditions such as high temperatures. In the context of this presentation, Unobtainium is more narrowed down to include superior materials with multifunctional capabilities. Here, the search for Unobtainium is carried out through the incorporation of graphitic based carbon, in the form of carbon nanotubes (CNTs) and nanofibers (CNFs). Through their highly stable crystalline structures, formed at high temperatures (as high as 2000°C), these materials offer remarkable mechanical properties and thermal stability, and excellent electrical conductivity. Moreover, compared to high strength carbon fibers these materials offer much higher surface to volume ratio, which can be exploited to achieve better bonding with matrices. Despite their many advantages, the incorporation of CNTs and CNFs in nanocomposites to obtain desired properties at macroscale is elusive. That is mostly due to limitations in achieving high concentration of these nanomaterials in polymeric matrices and the relatively inactive surfaces of these materials, which results in premature mechanical failures due to CNT/CNF pull out. In this study, these limitations are efficiently pushed back by developing a novel method to achieve macroscale CNT-based yarns which contain up to 80 wt.% of the CNTs. In this method, polymer matrices in forms of solutions are sprayed on stable networks of nanomaterials. Moreover, inspired by design principles in nature, the interactions between CNTs are engineered to benefit from H-bonds, which can break and reform upon deformation, to achieve yarns with specific strength and toughness that are several times higher than for instance Aluminum alloys. Regarding CNFs, this presentation will focus on an on-going research aimed at optimizing the structure of CNFs obtained through pyrolysis by controlling the process conditions. The current research points to an optimal thermal treatment through which high performance CNFs with desired crystalline structure could be achieved.

BIO

Dr. Mohammad Naraghi received his B.Sc and M. Sc degrees in 2002 and 2004 both from Sharif University of Technology, Tehran, Iran, from the department of Civil engineering. His M.Sc research was on the fracture mechanics of fiber reinforced cement based composites. In 2005, He joined the research group of Professor Ioannis Chasiotis in the University of Illinois at Urbana-Champaign, department of Aerospace engineering, where he was graduated with Ph.D degree in October, 2009. His PhD research was in the field of nanomechanics and the application of MEMS sensors and actuators to investigate the mechanical behavior of soft nanofibers. His thesis research received the “Roger A. Strehlow Memorial Award” for outstanding research accomplishments. The award is presented annually by the Aerospace engineering department at UIUC to one graduate student in recognition of his/her outstanding research accomplishment. Since then, Dr. Naraghi has been working as a post-doctorate research fellow in the research group of professor Espinosa at Northwestern University. His main field of expertise is in bio-inspired high performance light-weight nanocomposites, nanomechanics, mechanical characterization of soft nanostructures, and application of MEMS to nanomechanics. In addition to Roger A. Strehlow Memorial Award, he is the recipient of several academic and scientific awards including the Sandia National lab award in “Characterization, Reliability and Nanoscale Phenomena” in MEMS in two successive years, 2007 and 2008, and the best paper award in the Continuum Mechanics conference held in Cambridge in 2009.