FROM STRUCTURAL TO FUNCTIONAL COMPOSITES: A PERSONAL JOURNEY

Tsu-Wei Chou

University of Delaware, Newark, Delaware, USA

Spectacular evolution has taken place in the field of advanced composites during the past half century. It has been a privilege to witness some of the tremendous changes. This lecture focuses on my personal experience in composites research during these years. The evolution of functional composites is presented in the context of traditional structural composites.

Traditional structural composites, which form the bases of this presentation, are short fiber, hybrid, textile and flexible composites. The functional composites to be discussed include carbon nanotube based continuous fibers, nanocomposites, electromagnetic wave absorbing composites, energy storage devices and sensors. The application of continuum and molecular mechanics will also be discussed. The following outline is given in terms of the particular correlations between a traditional structural composite and recent development in related functional composites.

(A) Interest in short fiber and particulate reinforced polymeric, ceramic and metal matrix composites in the 1970s and ’80s energized tremendous research effort in the mechanics, processing and strength studies of these composites. Two examples of more recent applications of short fiber composites can be found in continuous fibers based on carbon nanotubes as well as dispersion of carbon nanotubes in traditional fiber composites as damage sensors.

(B) The concept of hybridization of fibers enables the optimization of strength and failure behavior of composites. The search for “hybrid effects” and the synergism among component phases in the early days focused mainly on the mechanical behavior of composites. Most of today’s functional composites are actually hybrids. An interesting application of hybrid composites can be found in a unique electromagnetic wave absorbing composite based on nanocarbons and nanoparticles.

(C) The emergence of both analytical/modeling tools and fabrication technology for 2D and 3D textile preforms generated tremendous interest in the development of textile structural composites in the 1980s. The concept of through-the-thickness reinforcement enabled significant damage tolerance particularly in thick-section composites. The more recent advent of 3D printing has motivated the microstructural design of a broad range of preforms as well as their fabrication using fused deposition modeling. This new capability opens up tremendous opportunity in enhanced structural designability and realization of mass customization.

(D) The idea of endowing large flexibility in fiber composites through control of the reinforcement morphology stimulated much research interest in the design and fabrication of flexible composites. The concept of flexible composites has enabled recent rapid developments in stretchable energy storage devices based on assemblies of nanocarbons through prestressing.

(E) Comments will also be made regarding the analysis and modeling of micro-cracking in cross-ply fiber composites and buckling of graphene films.

Biography

Dr. Tsu-Wei Chou is the Pierre S. du Pont Chair of Engineering at the University of Delaware. Dr. Chou received the Ph.D. degree in materials science from Stanford University (1969). He is the author of several books, including *Microstructural Design of Fiber Composites*, Cambridge University Press, England (1992). Dr. Chou is a Fellow of ASME, ASM, ASC, ACerS, TMS and AIAA, and he is a recipient of the Charles Russ Richards Memorial Award, the Worcester Reed Warner Medal and the Nadai Medal of ASME, the Distinguished Research Award and the ASC/DEStech Award in Composites of the American Society for Composites, and the Francis Alison Medal and the Medal of Excellence in Composite Materials of the University of Delaware. Dr. Chou is the Editor-in-Chief of the international journal *Composites Science and Technology*. He has been recognized by ISI as a "Highly Cited Researcher," and he was named one of the top 100 materials scientists (ranked 34th) of the past decade (2000-2010) by Times Higher Education. Dr. Chou has been honored as a World Fellow by the International Committee on Composite Materials. He was recently selected to receive the 2017 Albert Sauveur Achievement Award of ASM International.