Polymer Physics and Engineering: Flow, Bounce, and Break – the whole nine yards

Abstract: Polymeric materials are widely used to achieve light-weight mechanical performance. Thus mechanics of polymers should be a core subject in polymer science and engineering. This seminar will discuss all aspects of mechanical characteristics of polymers in their different forms: melt/molten, glassy vs. semicrystalline (plastics) and crosslinked (elastomers vs. thermosets). In the liquid state, nonlinear polymer rheology [1] must be established on firm experimental and phenomenological grounds to guide polymer processing. Once the relation between mechanical property of solid polymers and structure is understood, we would like to figure out how structures at the chain level, e.g., chain networking through molecular uncrossability, can be affected by melt deformation and crystallization so that the property-structure relation can be further examined. As an example of processing-structure-property (P-S-P) relationship, the presentation will show how pre-melt-stretching allows brittle poly(lactic acid) to make a super tough, transparent and heat resistant PLA cup through nano-confined crystallization [2]. Besides ductility [3], another mechanical characteristic is the ability to resist crack propagation or fracture, a topic belonging to the subject of fracture mechanics. The ultimate question here is what structures lead to strongest polymers. What determines the inherent strength of solid polymers? Are solid polymers flaw-tolerant [4]? Does brittle fracture of polymers arise from flaws introduced by impurities (e.g., dusts)? This seminar will address these basic questions by showing how nonlinear polymer rheology, molecular mechanics and fracture mechanics of solid polymers can be treated in a unified framework to establish P-S-P relationship for polymers of all forms, providing the required knowledge base for development of sustainable polymeric materials.


Bio: Shi-Qing Wang arrived in US in fall 1982 through the CUSPEA program. He received PhD in physics from University of Chicago in 1987, working on hydrodynamic theory of dilute polymer solutions under Karl Freed. After two years of postdoctoral research at UCLA, Shi-Qing Wang joined Macromolecular Science and Engineering Department at Case Western Reserve University in fall 1989. He moved to University of Akron in fall 2000. Since 2011 he has been Kumho Professor of Polymer Science and named Distinguished Professor in 2022. He has published his first book Nonlinear Polymer Rheology in 2018 to show how a new paradigm describes the subject. In the subsequent and current episodes, he focused on molecular and fracture mechanics of polymers in all forms (i.e., plastic, elastomeric and thermosetting). He plans to write a second book to summarize the emerging knowledge and understanding on all aspects mechanical of solid polymers. He was elected APS fellow in 1997 and AAAS fellow in 2014.