A Snapshot into the Evolution of Manufacturing, Characterization, Modeling Efforts to Tailor Function-Performance Strategy in Composites

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ABSTRACT

The role of traditional tape or textile driven manufacturing approaches to produce large components and structures have encountered and overcame their share of difficulties leaving us with pragmatic lessons learned. In the last decade, as the quest for miniaturization, autonomous and multifunctional systems have accelerated, new approaches emerged to tailor in desired effects at multiple scales. Furthermore, the intersection of infra-structure, transportation, energy and health industries is leading the research communities to envision novel methods to achieve simultaneously the desired mechanical-physical-biological properties. With the emphasis on nanofabrication and additive manufacturing, potential breakthroughs to deliver repeatability and sustainability are eminent. For example, the abundance of CNTs has pushed its way into both organic and inorganic matrices to modify, strength, toughness, conductivity. The advances in 3D printing technology have created a vast interest to build complex geometries only to be held back by lack of understanding of kinetics at as low as atomistic scales. One can readily witness the insitu characterization demands to address microstructure evolution in a temporal manner as a function of actual processing conditions.

In this spirit of function-performance strategy, herein we will share our work exploring the essentials in creating an effective interface in two different systems; namely, (a) between metal foil (Ti, NiTi) and high temperature carbon reinforced polymer composites, and (b) carbon foam (b.1) infiltrated with HA-PLGA, (b.2)coated with Cu. Novel techniques such as incorporating laser ablated metal foils, specifically functionalized sol gels for high temperature matrices, CNT modified textile layers will be discussed for the metal-composite interfaces. The results from the extensive characterization of this interface through optical microscopy, scanning electron microscopy, energy dispersive spectroscopy and atomic force microscopy/nano infrared spectra will be reported. The subsequent mechanical and thermomechanical coupon tests (DCB) and their corroboration with the computational models and DIC measurements provide further validation of the need to engage comprehensive –interdisciplinary tools to develop delamination resistant interfaces at multiple-scales. In the carbon foam infiltrated with HA-PLGA study targeted for orthopedic applications, we observe good interfacial bonding as well as osteoblast adhesion. The results from the in-vitro hydrolytic degradation also support the premise of osseointegration. Carbon foam coated with copper study will be used to elucidate the multifunctional aspects through integrated processing, testing, and μCT-tomography driven computational models.

Dr. OZDEN OCHOA, Fellow of the American Society of Mechanical Engineers, Fellow of the American Society for Composites and World Fellow of ICCM, is Professor Emerita and TEES Research Professor in the Department of Mechanical Engineering at Texas A&M University. Her research focus on computational and experimental mechanics of composites in aerospace, offshore, automotive and medical applications have culminated in over 200 publications and one book. In addition to her academic commitments, Dr. Ochoa had the privilege of serving at DOD research laboratories; as the Associate Director for Science & Technology at ARL, interim Director of Aerospace Sciences and Materials Directorate at AFOSR, as Composites - ST at the Materials and Manufacturing Directorate at AFRL and as a Program Manager at AFOSR building the portfolio for mechanics of composites. She has served on review boards of numerous journals, national and international agencies including NATO Science for Peace Projects. Among her many honors are the ASTM D30 Wayne Stinchcomb Memorial Award, American Society for Composites-Destech Award in Composites; American Society of Mechanical Engineers Dedicated Service Award; Texas A&M University International Excellence Award.