Design and Fabrication of Complex Flexible Structures and Microarchitectures

The ability to design and fabricate complex flexible structures is becoming increasingly important for enabling next-generation technologies (e.g., microarchitectures that possess radically superior properties compared with those of naturally occurring materials, high-precision multi-degree-of-freedom flexure-based motion systems, and tip-tilt-piston micro-mirror arrays that steer light with unprecedented speeds). In contrast with their rigid-body counterparts, flexible structures achieve their motions through the deformation of their compliant elements and thus they *(i)* achieve high resolution and repeatability, *(ii)* require no lubrication, *(iii)* experience minimal friction and wear, *(iv)* are easily maintained, and (v) often cost significantly less than other competing precision bearing technologies (e.g., magnetic or air bearings). Despite their many advantages, many engineers avoid using flexible structures because design tools for creating them are limited and modeling tools for analyzing their kinematics and stiffness characteristics are complex and unapproachable due to substantial nonlinearities. The Freedom, Actuation, and Constraint Topologies (FACT) design approach has, however, been successfully applied to the design and analysis of flexible structures of any complexity. The basis for FACT is a comprehensive library of geometric shapes that represent the mathematics of screw theory, projective geometry, and constraint-based design. These shapes enable designers to visualize the regions wherein various flexible elements can be placed for achieving the desired kinematic, elastomechanic, and dynamic characteristics. In this way, designers can rapidly consider and compare every concept that best satisfies the design requirements before selecting the optimal concept. In this seminar, a multiplicity of FACT-designed flexible structures and microarchitecture examples will be provided and new additive fabrication approaches will be proposed as viable solutions for fabricating them over a broad range of size scales.