INDUSTRIAL AND SYSTEMS ENGINEERING | TEXAS A&M ENGINEERING

Department of Industrial and Systems Engineering

Dr Satish T. S. Bukkapatnam

Prediction of Complex Systems Evolution: Towards Real-time Monitoring of Nanomanufacturing Processes

Monday, March 18, 1:50 – 2:40
4002 Emerging Technologies Building

Abstract:

Real-time quality monitoring is considered essential for the translation of various ultraprecision and nanomanufacturing technologies into viable industrial processes. For instance, many microelectronics and structural applications necessitate precise *in situ* control of the lengths of carbon nanotubes (CNTs) and other nanostructures. Atomistic Monte Carlo (MC) models are particularly suited for real-time monitoring of nanomanufacturing processes as they can bridge the time-scales of the complex nanostructure growth mechanisms (picosecond range) with the time-resolutions of online sensors and characterization instruments (10^{-3}–10^{2} sec). However, computational overhead currently limits MC models to simulating only the early stages of nanostructure growth from nanomanufacturing processes.

This talk will introduce an approach to speed-up MC models for real-time monitoring and control CNT lengths in a chemical vapor deposition process. The approach is based on a finding from simulation experiments that the CNT growth process exhibits nonlinear and recurring near-stationary dynamics. Topological characteristics of this complex dynamics are employed as part of a nonparametric local Gaussian process (LGP) meta-model for predicting the nanostructure evolution. Initialization of the relaxation procedure (the most computationally intensive step in MC simulations) with LGP predictions reduces the simulation time by an order of magnitude (70-80%) compared to conventional atomistic and meso-scale models, leading to the growth of one of the longest (~194 nm) reported CNTs from atomistic simulations. Extensive simulations and limited experimental studies indicate that the length estimates together with intermittent measurements from characterization instruments can be used to control CNT lengths to within 1 nm of the specifications.

Bio:

Satish T. S. Bukkapatnam serves as an AT&T Professor of Engineering at Oklahoma State University (OSU). His research addresses the harnessing of high-resolution nonlinear dynamic information, especially from wireless MEMS sensors, to improve the monitoring and prognostics of ultraprecision and nanomanufacturing processes and machines, cardiorespiratory processes, and other complex infrastructure and lifeline systems. His research has led to 123 peer-reviewed publications (71 published/ accepted in journals and 52 in conference proceedings), 5 pending patents, $4.5 million in grants as PI/Co-PI from NSF, DoD and the private sector, and ten best-paper/poster recognitions. He was recognized as OSU Regents distinguished researcher (2011), Halliburton outstanding college of engineering faculty (2011 and 2012), IIE Eldin outstanding young industrial engineer (2012) and SME Dougherty outstanding young manufacturing engineer (2005) awards. He received his MS and PhD degrees from the Pennsylvania State University.