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**VALIDATION, ERROR ESTIMATION, UNCERTAINTY
QUANTIFICATION, AND CONTROL OF MULTISCALE MODELS
IN NANOMANUFACTURING**

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Three of the major challenges to advances in computer modeling and simulation are: 1) the tyranny of scales, referring to the disparity in spatial and temporal scales encountered in many contemporary models of scientific and engineering problems, 2) the curse of dimensionality, referring to the explosion of the size of models encountered where statistical data and stochasticity are taken into account, and 3) predictive modeling, referring to the use of verification and validation of processes and quantification of uncertainty in computer predictions. These three issues are addressed in this lecture in connection with multiscale models used in studying nanoscales manufacturing processes. A process of multiscale modeling is described that makes use of a posteriori estimates of modeling error. As a byproduct, methods for solution verification are developed. This is demonstrated on molecular models of polymers used in imprint-lithography semi-conductor manufacturing. Then, issues of stochasticity are considered, and methods for solving large stochastic systems are reviewed. Finally, a general approach to statistical model calibration, validation, and uncertainty quantification is presented, which is based on Bayesian inference. Several algorithms that provide the foundation of such statistical modeling approaches are described.

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