Micromechanics: The “Strength” of Miniaturized Testing

Erica Lilleodden

Fraunhofer Institute for Silicon Technology (ISIT), Germany
e-mail: erica.lilleodden@isit.fraunhofer.de

The continued miniaturization of engineering systems and the increasing complexity of multimaterial architectures demand characterization approaches capable of resolving mechanical behavior at the length scales where deformation, damage, and failure originate. Conventional testing methods often fail to capture the localized phenomena governing performance, particularly when the representative volume approaches the characteristic dimensions of the microstructure and pronounced size effects emerge. This presentation highlights recent advances in quantitative small-scale mechanical testing and nanomechanical characterization that enable direct correlations between processing, local microstructure, and performance, going well beyond investigating the “smaller is stronger” paradigm. Emphasis is placed on distinguishing intrinsic material behavior from testing artifacts and on establishing robust constitutive descriptions for microscale materials and device components. By integrating advanced microstructural characterization with micromechanical testing, this framework provides powerful tools for accelerated process optimization, root-cause failure analysis, and predictive lifetime assessment across a broad range of material systems and applications. Ultimately, the talk demonstrates how miniaturized testing has evolved from a characterization technique into a quantitative diagnostic methodology, revealing that the reliability and functionality of advanced materials are fundamentally governed by local mechanical behavior across multiple length scales.