Finite Element Analysis of Atomic Force Microscopy (AFM) Measurement of Inhomogeneous Nodules Suspended in a Membrane

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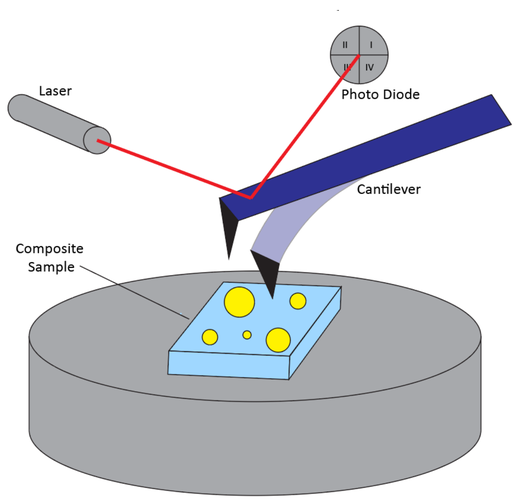
Abstract

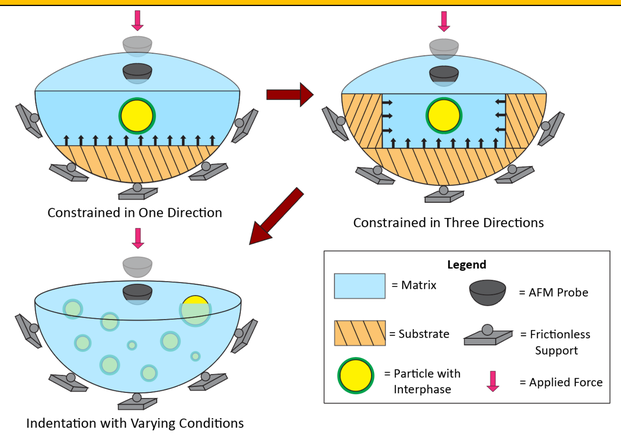
Inclusions and particles within nanoscale products affect their macro- and micro-scale properties, so those particles and the surrounding area must be characterized to improve product quality. Atomic force microscopy (AFM) is a powerful technique that has been used to characterize such materials; however, interactions between the AFM indenter and the particles result in complex force-displacement data. In this research, finite element analysis (FEA) is used to model AFM performed on particles within a membrane to better understand their material properties and deconvolute materials properties and structural effects in AFM data.

AFM Peak Force QNM



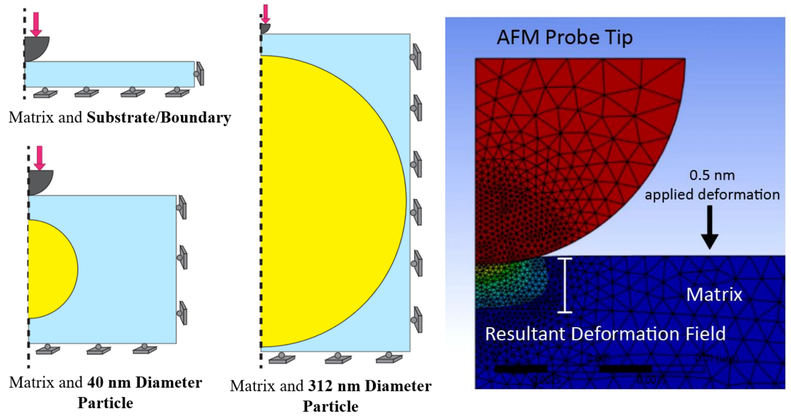
Graphic representing the indentation of an AFM Peak Force QNM probe into a particle-matrix composite

Varying Geometry



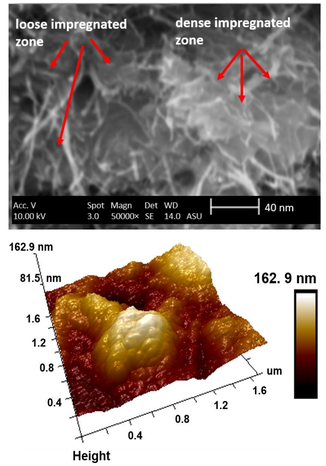
Representations of various geometries, levels of confinement, and boundary conditions that are present in particle-matrix composites

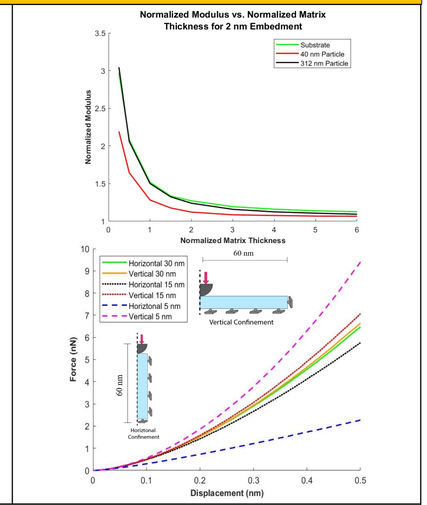
Finite Element Analysis

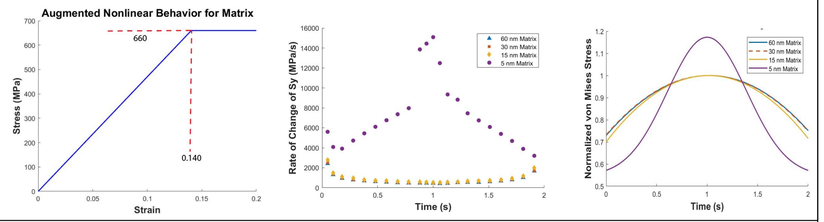


Geometry of FEA, with an example of a FE probe indenting into a matrix

Results







-A large particle—comparted to the probe—will act like a rigid substrate
-Horizonal confinement varies from vertical confinement when the matrix has low rigidity or fixity
-The augmented local yield strength can be modeled at the nanoscale until a critical amount of stress is reached, at which point the model fails

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