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Quantitative in situ nanomechanical characterization by combining scanning probe microscope and scanning electron microscope

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ABSTRACT

The great effort is being placed in the design of new characterization techniques and the construction of new instruments capable of characterizing the mechanical response of nanoscale materials. However, property measurements of nanoscale object, such as nanowires and nanothin film, are extremely challenging because of their miniscale size. The main challenges in the experimental study of nanoobject include: (1) real observation of the nanoscale object during mechanical testing; (2) manipulation and positioning of specimens with nanometer scale accuracy; and (3) measurement of force and deformation with nano-Newton and nanometer level resolution. Hence, it is necessary to develop a new experimental testing setup to perform fast and accurate mechanical characterization of nanoobject. The SEM is powerful tool to perform online observation of nanoscale object with large chamber which provides the opportunity to integrate physical or mechanical property measuring system for in situ experimentation. On the other hand, scanning probe microscopy (SPM) or atomic force microscopy has been employed extensively as a high resolution force and displacement measurement tool to characterize the mechanical property of nanoscale object. In this study, we introduce a quantitative nanomechanical in situ test platform by implementing a home-made SPM head in SEM chamber. The SPM/SEM hybrid system has been capable of a wide range of quantitative nanomechanical characterized functions, including three-point bending, uniaxial tension, compression, and nanoindentation. The methodlogies to obtain force versus displacement measurements to extract quantitative material properties are also presented in detail. We show the efficacy of this integrated system by the in situ three-point bending and nanoindentation experiments for individual nanostructure.

KEY WORDS

scanning probe microscopy, nanomechanical, individual nanostructure, scanning electron microscopy