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IN-SITU ELECTRON MICROSCOPY TESTING OF 1-D NANOSTRUCTURES

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ABSTRACT

Over the past decade, there has been a substantial thrust to reduce the size of electronic and electromechanical systems to the nano scale by fabricating devices out of thin films, carbon nanotubes (CNTs) and nanowires (NWs). In these applications, a thorough understanding of material mechanical, electrical and thermal properties as well as device performance and reliability requires the development of novel experimental approaches. In this presentation the design, microfabrication and operation of a MEMS based nanoscale material testing system (n-MTS, see Fig. 1) will be presented. Results obtained from *in-situ* SEM and TEM tensile testing of NWs and CNTs will be discussed. We will show that TEM imaging is required to properly assess the modulus and strength of multi-walled CNTs (MWCNTs) and demonstrate that the assumption of outer shell failure is not accurate in most cases. We will also discuss a change in failure mode as a function of electron and ion radiation.

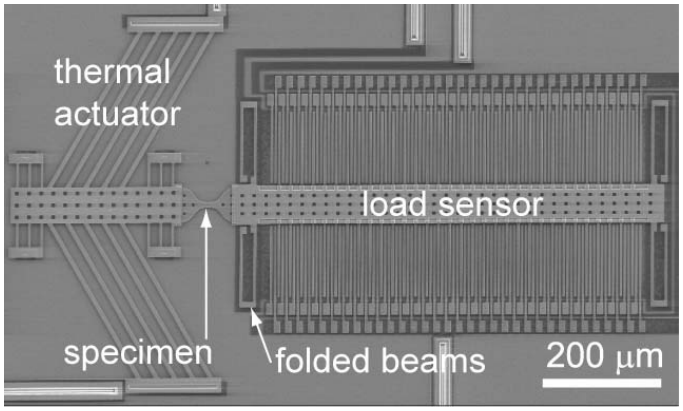

Figure 1 The n-MTS consists of a thermal actuator which provides displacement-controlled loading and a differential capacitive sensor to detect the corresponding load. The nanoscale specimen is mounted between the sensor and actuator.

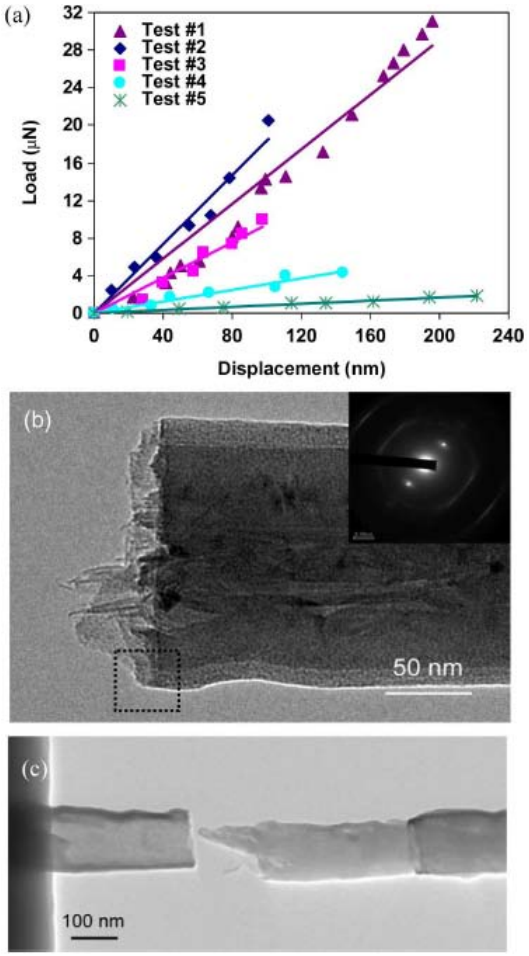

Figure 2 (a) Load-elongation measurements for MWCNTs tested under various irradiation conditions. (b) Typical fracture of a MWCNT subjected to ion beam irradiation showing failure

of the entire cross-sectional area (Test #1). (c) Typical fracture of a MWCNT subjected to e-beam irradiation showing telescopic failure with multiple-shells broken (Test #4).