The NEMS and Nano-Materials Laboratory

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The research in the NEMS and Nano-Materials Laboratory focuses on development of novel nano- and micro-electromechanical systems (NEMS/MEMS) as well as on investigation of the physical properties of nano-scale materials.

Among the MEMS/NEMS devices that will be developed are electrostatic and thermal actuators as well as miniaturized sensors, shown in Figure 1. Advanced image processing methods are developed and used in order to characterize the miniaturized devices under investigation. For example, image processing techniques developed for detection of nano-scale deflections is shown in Figure 2.

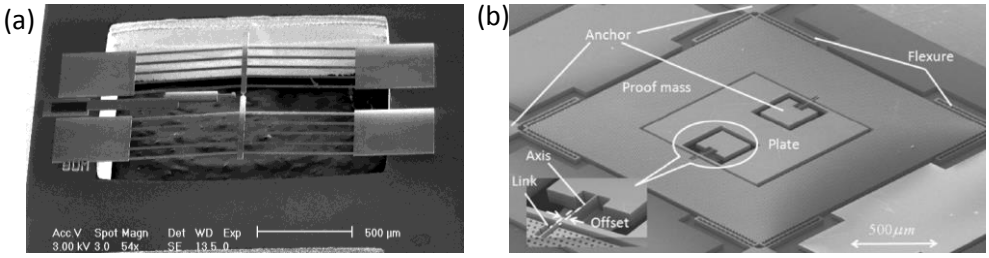

Figure 1. Scanning electron microscope micrographs of (a) micro-scale thermal actuator and (b) micro-accelerometer.

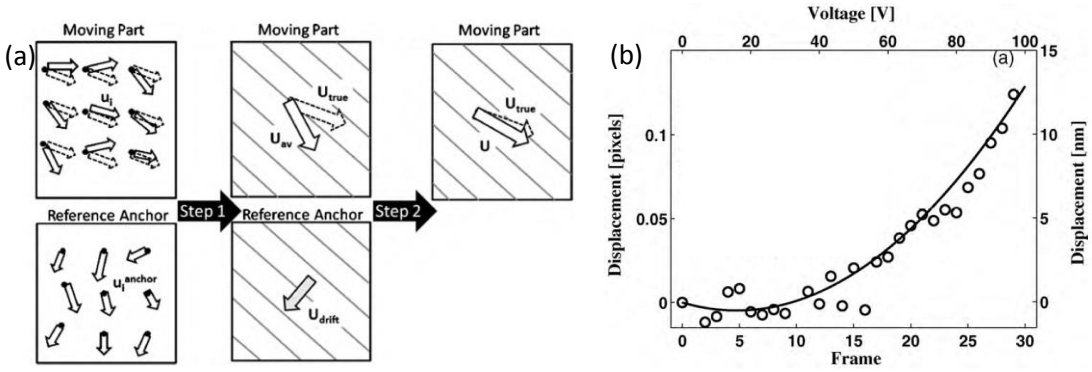

Figure 2. Image processing tools for detection of nano-scale deflections. (a) Image processing scheme, based on digital image correlation algorithm. (b) Measured nano-scale deflections.

Nano-scale materials are thoroughly investigated. Due to their excellent fabrication process compatibility, MEMS devices are among the tools used to manipulate nano-materials, as demonstrated in Figure 3. An example of an investigation of the capacitance properties of vertically-aligned carbon nanotube is shown in Figure 4, where it was demonstrated that vertically-aligned carbon nanotube micro-structures behave as Faraday cage, screening electrostatic fields.

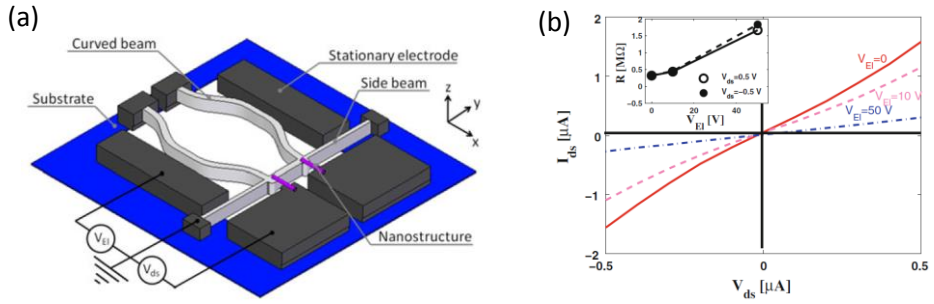

Figure 3. (a) Schematics of a MEMS device used to manipulate nano-materials. (b) Measured electrical characteristics of carbon nanotube under strain.

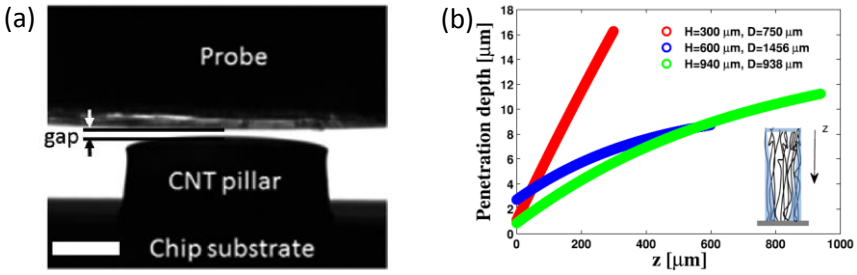

Figure 4. Characterization of vertically-aligned carbon nanotube micro-pillars. (a) Optical image of the measurement setup. (b) Penetration depth of an electrostatic field into vertically-aligned carbon nanotube micro-pillars.

Selected Papers

- A. Ya'akobovitz, M. Bedewy and A.J. Hart, "Electrostatic capacitance and Faraday cage behavior of carbon nanotube forests", *Applied Physics Letters*, vol. 106, article number 053106, 2015.

- A. Ya'akobovitz, S. Krylov and Y. Hanein, "A MEMS nano-extensometer with integrated mechanical de-amplifier for testing nanostructures under tension", *Microsystem Technologies*, vol. 17, Issue 3, pp. 337-345, 2011.

- A. Ya'akobovitz, S. Krylov and Y. Hanein, "Nanoscale displacement measurement of electrostatically actuated micro devices using optical microscopy and digital image correlation", *Sensors and Actuators A*, vol. 162, pp. 1-7, 2010.

- A. Ya'akobovitz and S. Krylov, "Towards sensitivity enhancement of MEMS accelerometers using mechanical amplification mechanism", *IEEE Sensors Journal*, vol. 10, no. 8, pp. 1311-1319, 2010.

- G.A. Karp, A. Ya'akobovitz, M. David-Pur, Z. Ioffe, O. Cheshnovsky, S. Krylov and Y. Hanein, "Integration of suspended carbon nanotubes into micro-fabricated devices", *Journal of Micromechanics and Microengineering*, vol. 19, article number 085021, 2009.