doi:10.1017/S1431927611006763
Microsc. Microanal. 17 (Suppl 2), 2011

Retrofittable Nano-Manipulation Systems for Scanning Electron Microscope

P. Woo*, M. Nakamura*, D. Hoyle* I. Cotton*, Y. Zhang**, B. Chen**, Yan. Zhang** and Y. Sun**

* Hitachi High-Technologies Canada, Inc. 89 Galaxy Blvd., Toronto, Canada.
**Advanced Micro and Nanosystems Laboratory, Department of Mechanical Engineering, University of Toronto, Canada.

Traditionally SEM is often used as an instrument for providing high magnification images and analytical capability such as x-ray microanalysis. In recent decades different applications for SEM has been developed to focus characterizations of fine-scale materials such as in-situ annealing, micro-tensile testing, electrical resistivity measurements and grain boundary/texture analysis (EBSD). With the increasing demand in nanoscale characterizations, there's an increasing need to have a more sophisticated stage within the microscope. For example, a stage that would have "hands" built into the SEM stage to allow operator to manipulate objects at high magnification.

In this paper we presented a compact nanomanipulation system that is designed to be retrofitted easily onto many SEMs. Figure 1 shows the schematic of the nano-manipulation system inside the SEM. The system consist of 2 nanomanipulators (figure 1:a), a main stage holding the two manipulators (figure 1:b), a sub-stage holding the sample (figure 1:c) and two sets of mated connectors for connecting the nanomanipulators (figure 1:d). The size of each nanomanipulation system is around 80x110x45mm and this small foot print allow the entire system to be transferred/withdrawn anytime via sample exchange chamber (SEC) so high vacuum can always be maintained within the main chamber. This design also give user the flexibility to withdrawn the system completely when is not needed so it won't affect users' normal SEM workflow.

Each nano-manipulator can be equipped with different ends (called end-effectors) in order to perform different tasks within the SEM. The two nanomanipulators allow precise movement in all three directions. Each direction movement is controlled with a fine piezo-motor with a travel range of 10mm and a resolution of ~50nm. Moreover, the nanomanipulator can also be operated in fine positioning mode (i.e: as a piezo actuator) having a fine movement range of 1µm with a movement accuracy of ~1nm. It should be noted that a fully functional nano-manipulation system has been built and it's currently in the final phase of design changes and modifications for commercialization. A more detail design concepts and specifications of this nanomanipulation system has been published and described elsewhere by Zhang et al [1]. There are many new applications currently being developed using this novel nano-manipulation system. As a general overview, two applications will be briefly presented for: 1) maneuvering nanometer-sized objects by performing pick and place using nanogrippers, and 2) using microprobes for placing nanowire onto a dedicated MEMS device for mechanical characterization.

As discussed in earlier section, each manipulator can be fitted with different end-effectors in performing different tasks within the SEM. In this case, a microgripper type end-effector with miniaturized tips is used here for object manipulations. This nanogripper is fabricated using a standard microfabrication process [2] and then it is further refined using the focused ion beam (FIB) to reshape and sharpen the gripper tip-ends for improved manipulation of nanometer sized objects [3]. To further improve the pick and place process, a plunger is made in-between the two gripping arms to physically knock out the particle to facilitate release. Figure 2 shows an example of a microgripper with sharpen tips for particles manipulations.

The nanomanipulation system can also perform task that is beyond maneuvering of miniaturized objects. For example, the end-effectors can be fitted with microprobes to perform electrical resistivity measurements and even using SEM and nanomanipulator to accurately place an individual nanowire onto a MEMS tensile testing device for mechanical characterization [4].

FIG. 1 – Schematic representation of the nanomanipulation system

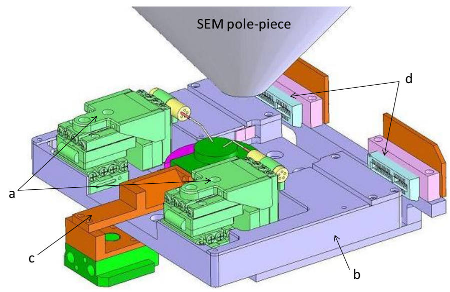


FIG 2. – Microgripper designed for nanoparticles manipulation within the SEM

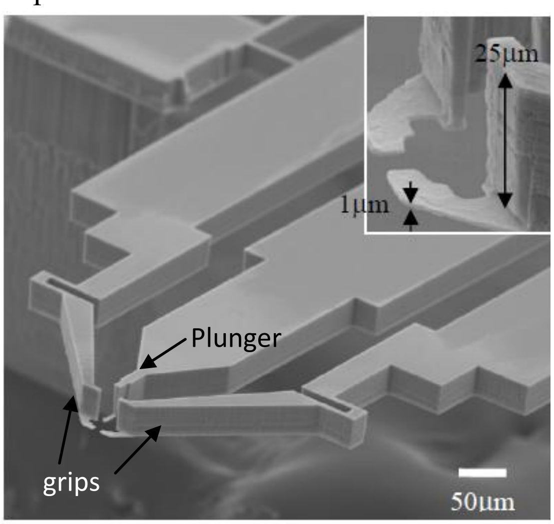
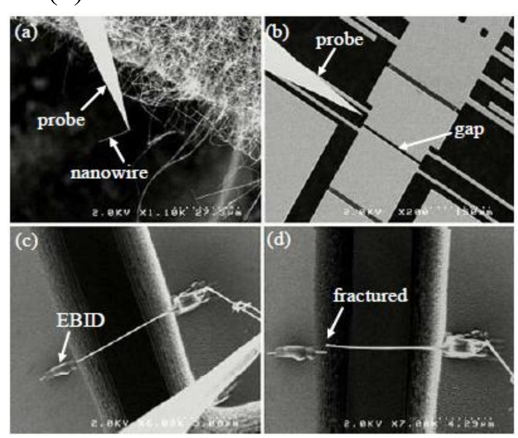


FIG 3 – Microprobes are used here to pick and place a Si nanowire (a,c) to a dedicated MEMS device (b) for a in-situ microtensile test (d)



References
[1] Zhang et al., submitted to IEEE (2011)
[2] Kim C.J., Pisano A.P and Muller R.S., J. of. Microelectromech. Sys. 1-1 (1992) 31
[3] Chen B.K., Zhang Y. Perovic D.D and Sun Y, IEEE International Conference on Micro Electro Mechanical Systems (MEMS'10) Proc., Hong Kong, (2010) 296
[4] Zhang Y., Xinyu L., Changhai R., Zhang Yan., Dong L., Woo P., Nakamura M., Hoyle D., Cotton I. and Sun Y., IEEE International Conference on Micro Electro Mechanical Systems (MEMS'11) Proc., Mexico, (2011) 625