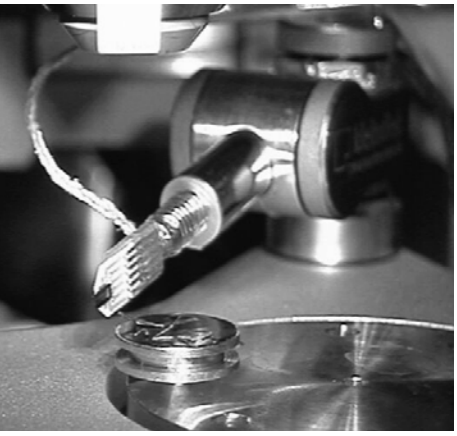
Tensile measurement case studies

Problem definition

Existing devices for mechanical testing have either the necessary spatial or the necessary force resolution, but they rarely have both. For example, micro-electro-mechanical systems (MEMS) meet the force resolution requirements, but usually only allow small displacements.

In addition, conventional AFM and nanoindentation-based systems are not usually suitable for in-situ testing. The few that are SEM/FIB compatible lack sufficient displacement and force resolution.

Another restriction of most systems is that they operate only in one predefined plane.

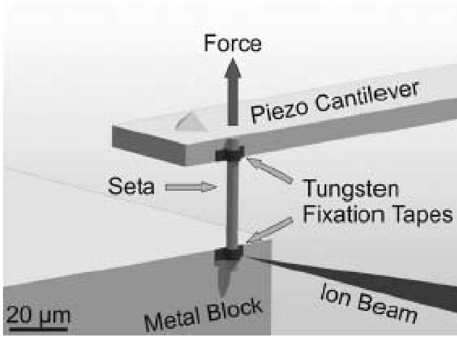


Micromanipulator fitted with force measurement system installed in an FIB

Solution

The MM3A-EM micromanipulator fitted with the FMS-EM plug-in tool can be used to overcome these limitations. Forces can be measured in a large working area in three planes of movement using a highly sensitive piezoresistive AFM tip.

While the FMS-EM is designed for forces in the micronewton range and lower, the LT12830 substage is an ideal tool for applications of this nature with force resolution requirements in the millinewton range. When fitted with a sensor, force measurements in two planes with direct displacement feedback are possible.



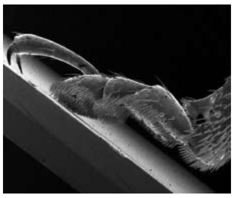
Attachment of the insect leg (*seta*) to the FMS-EM tip

Case study: MPI for Metals Research

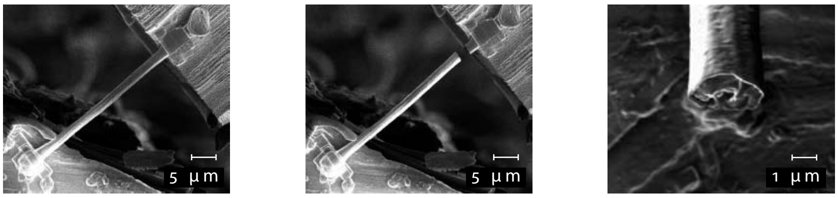
Researchers at the Max Planck Institute for Metals Research in Stuttgart approached us for a solution for conducting tensile measurements on biological structures, for example the hairs on insect legs.

Their goal was to analyze the mechanics of the insects and at the same time to determine the material parameters of the structures being analyzed.

Using the MM3A-EM micromanipulator fitted with an FMS-EM plug-in tool, they refined a novel in-situ method for mechanical testing of biological samples at the micrometer scale.



The foot of the beetle *Gastrophysa viridula* showing hundreds of adhesive hairs (*setae*)



The *seta* is attached to the FMS-EM tip and load is applied by moving incrementally away with the MM3A-EM micromanipulator until the maximum load is reached and the *seta* breaks

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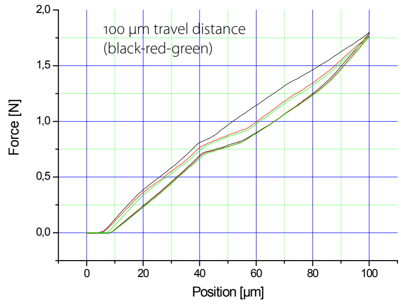
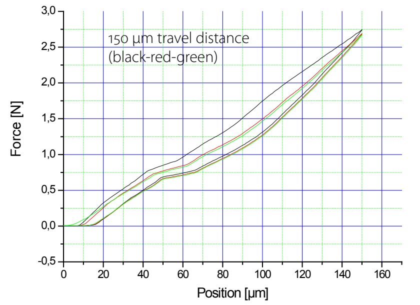
Case study: Tel-Aviv Unversity

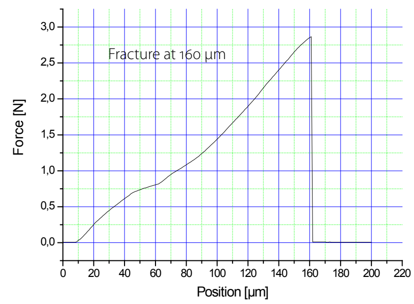
A group of researchers at Tel-Aviv University was interested in measuring the mechanical properties of various materials on the micrometer scale.

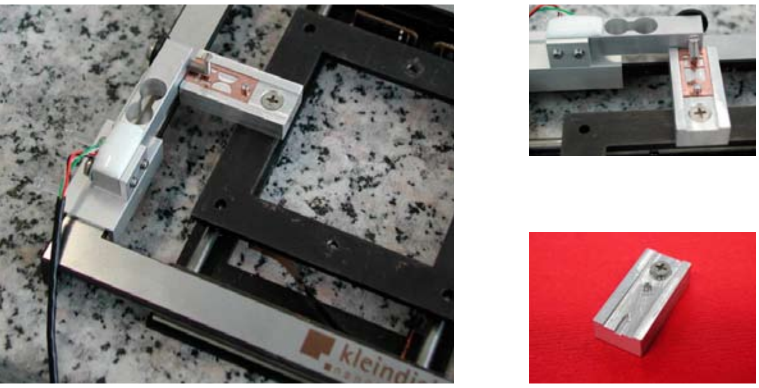
In the first stage, self-supported specimens of pure copper were fabricated by a combination of electro-deposition and conventional processing techniques for micro-electro-mechanical systems (MEMS).

The specimens had a dog-bone shape. The first objective of the feasibility test was to obtain a force-displacement curve in a uni-axial tensile test at room temperature and to relate the curve to microscopic observations.

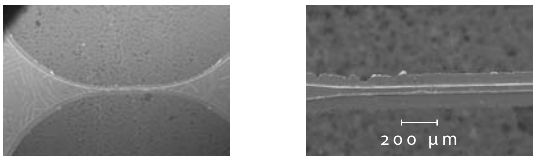






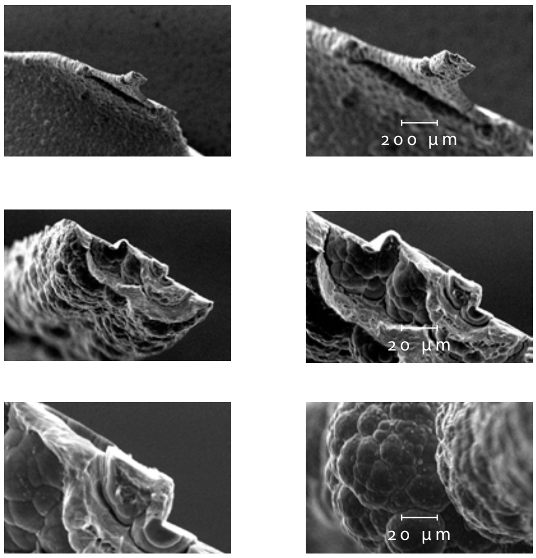


LT12830 substage fitted with a 6 N force sensor



SEM pictures of the specimen before the experiment

This was achieved in-situ using the LT12830 substage fitted with a 6 N force sensor. The combination of the displacement sensors on the substage and the force resolution of the sensor allowed this task to be realized with ease.



SEM pictures of the fractured specimen

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