



The SEM/FIB Workbench

Live Science Applications

Force-Distance Measurements:

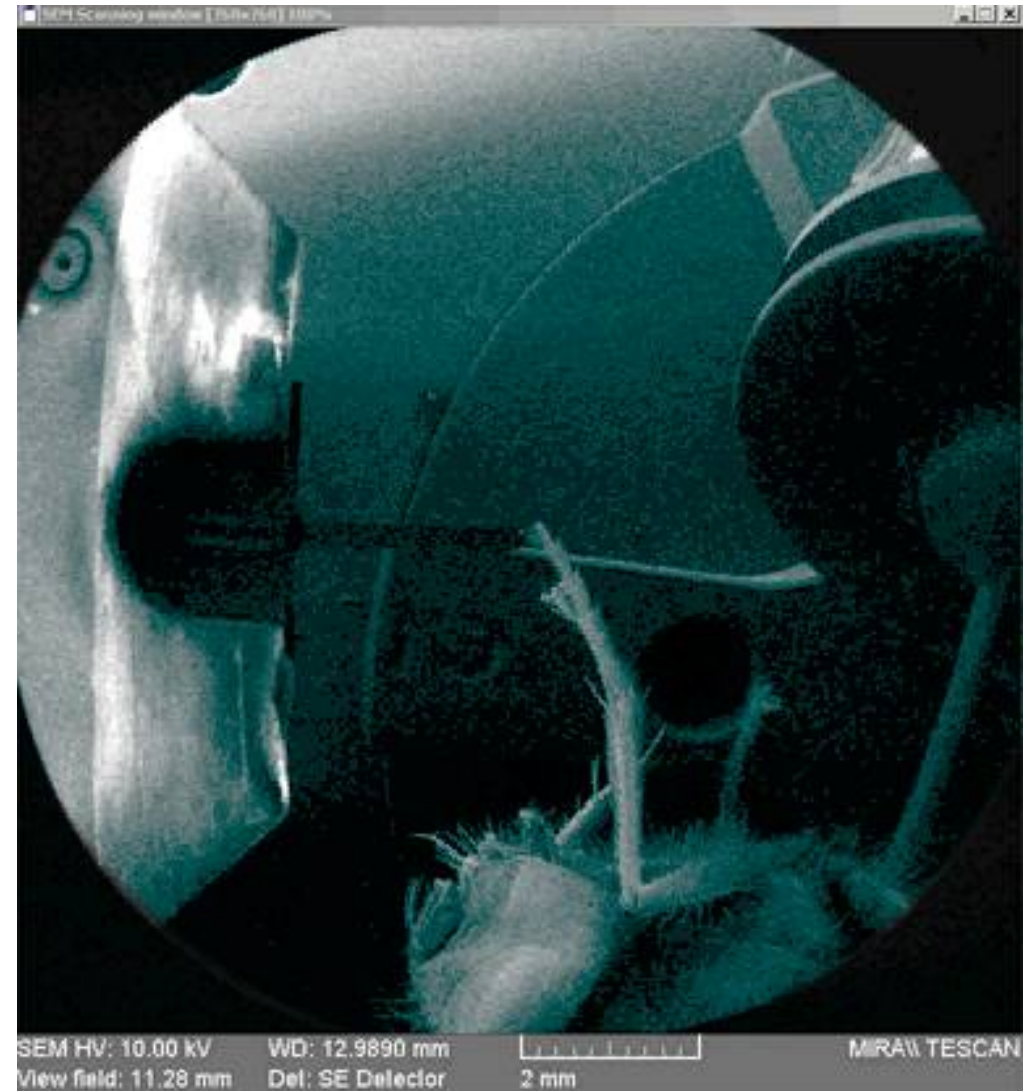
***Force-Distance Measurements at a Fly
inside of Scanning Electron Microscopes
with Nanorobotic Manipulators
from Klocke Nanotechnik***

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Force Distance Measurements

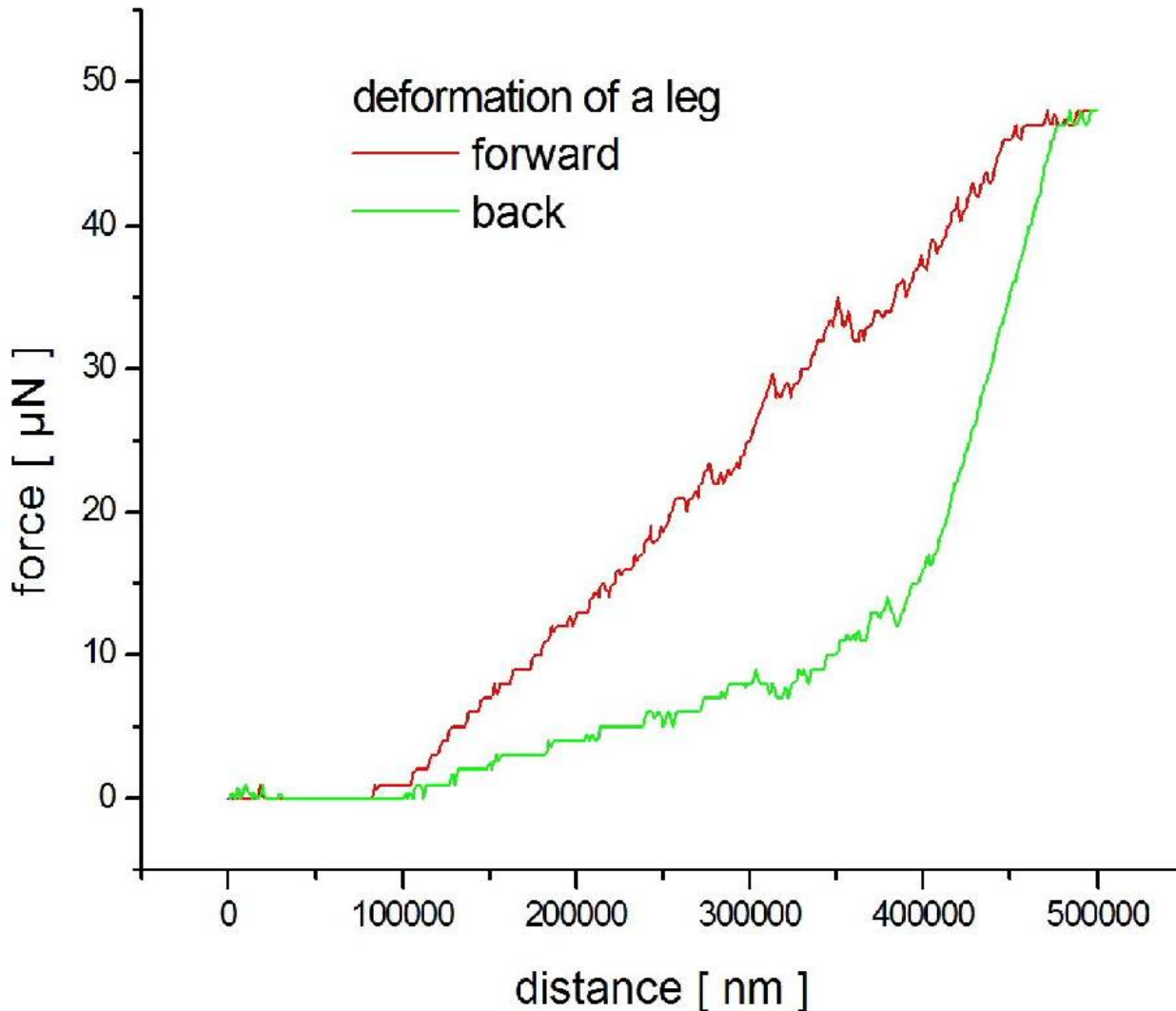
SEM image in Wide Field mode:

- A Nanorobotic Manipulator from Klocke Nanotechnik is equipped with a force sensor.
- The force sensor is moved from the left against the leg of a fly (center of the image)



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Force Distance Measurements



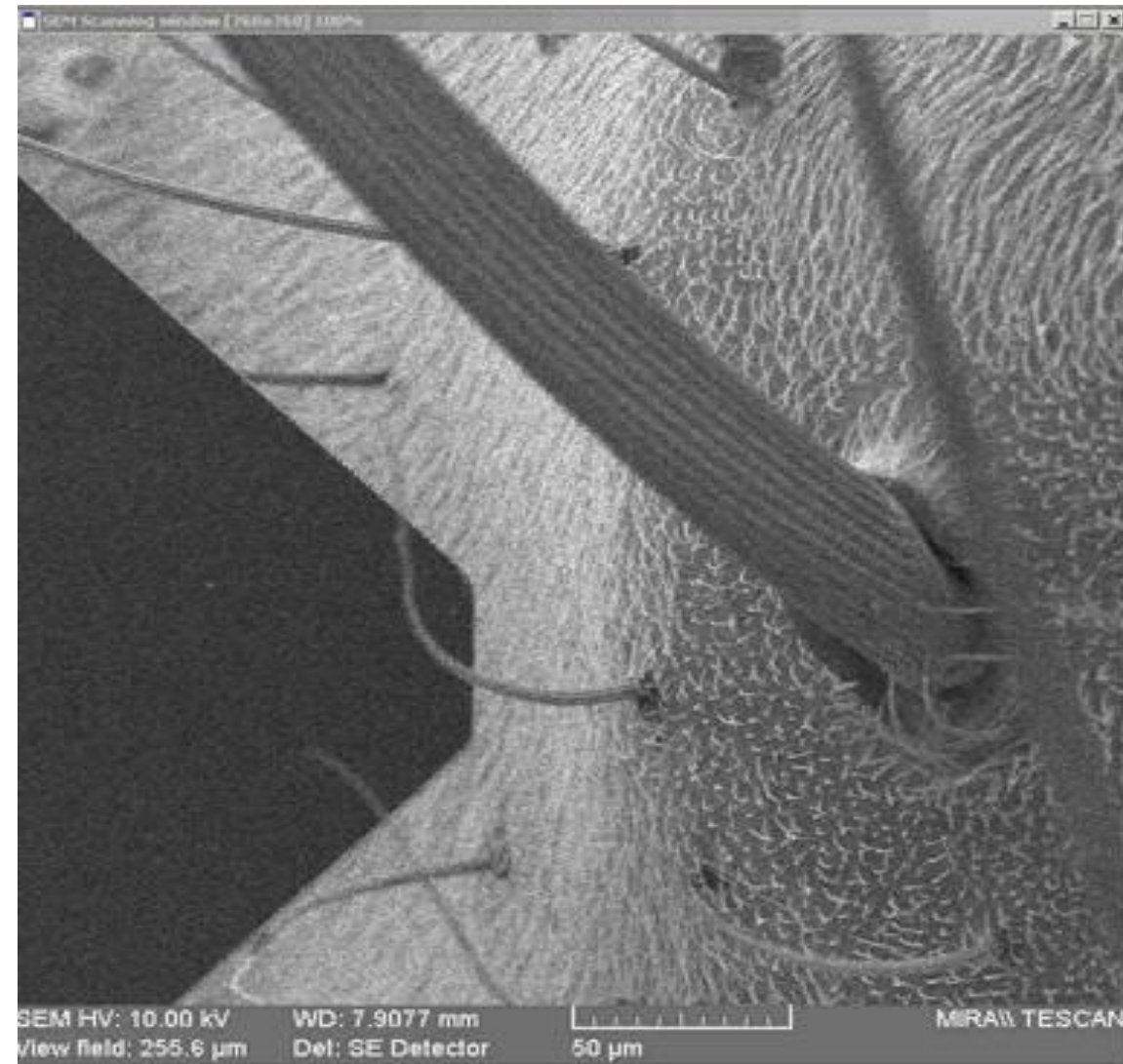
Force – Distance Diagram:

- Single nm resolution in displacement
- Force range depending on used sensor

Live Science Applications

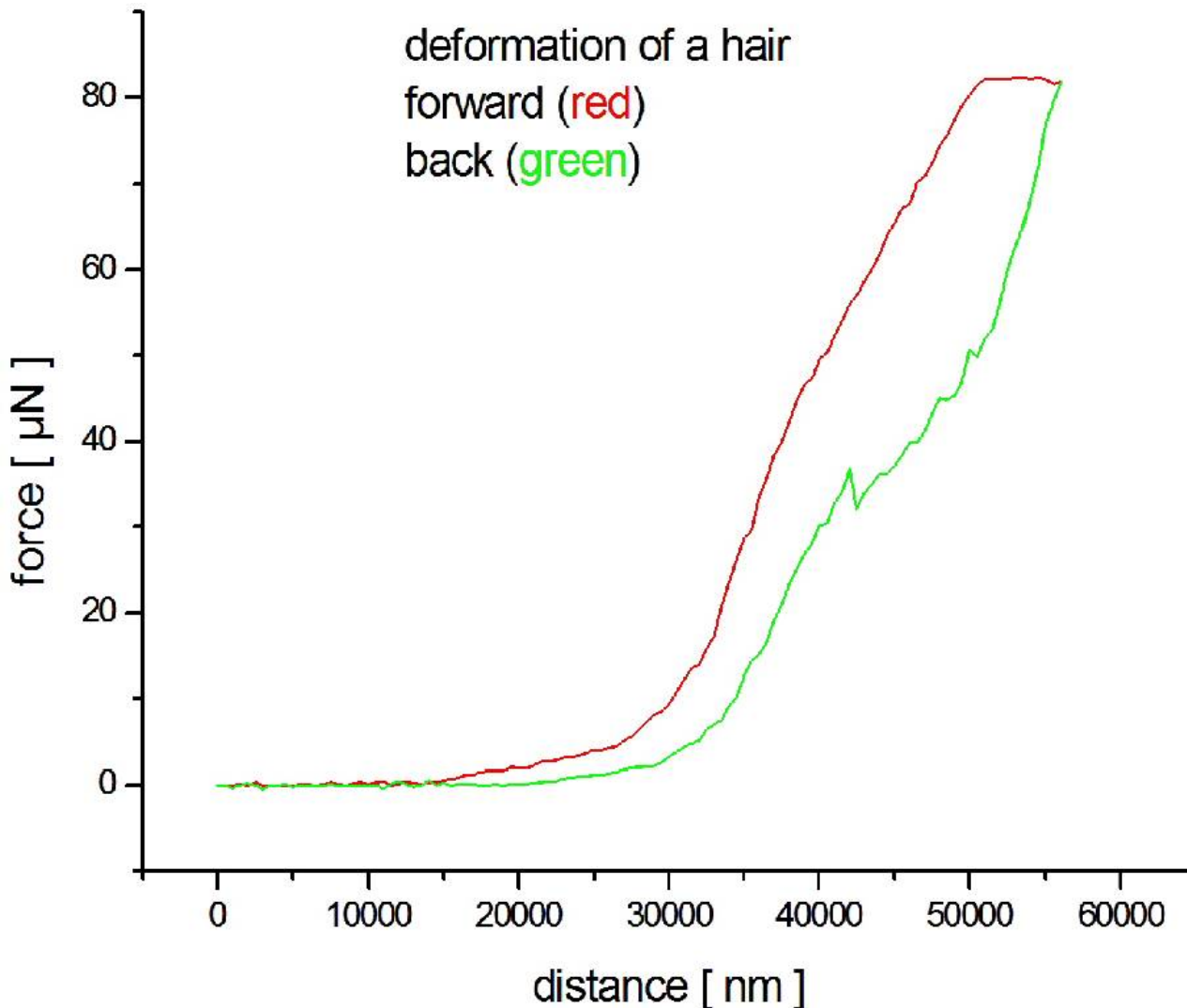
Force Distance Measurements

- The force sensor is moved from the left against the thin hair of a fly ...



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Force Distance Measurements



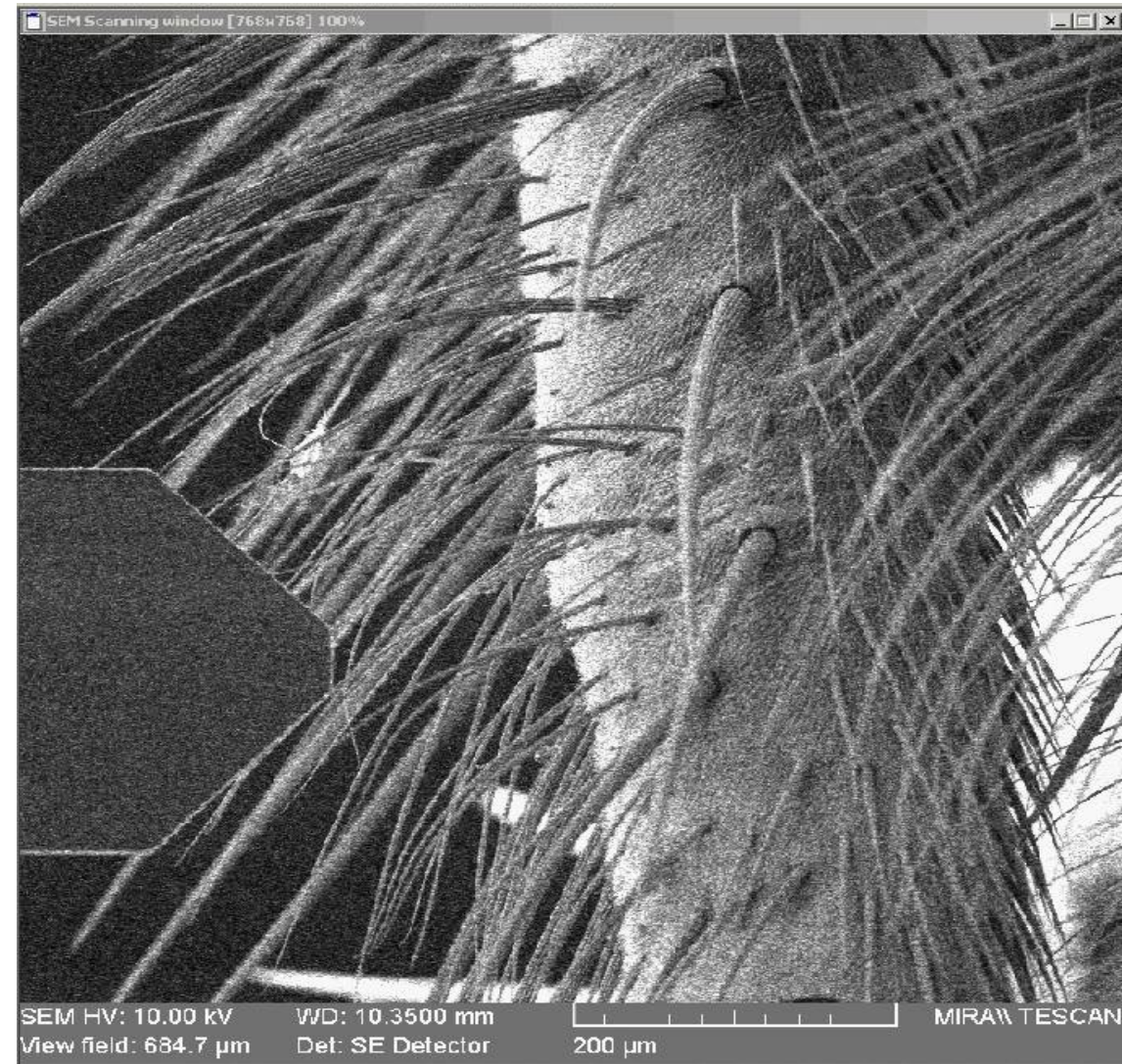
Force – Distance Diagram:

- Single nm resolution in displacement
- Force range depending on used sensor

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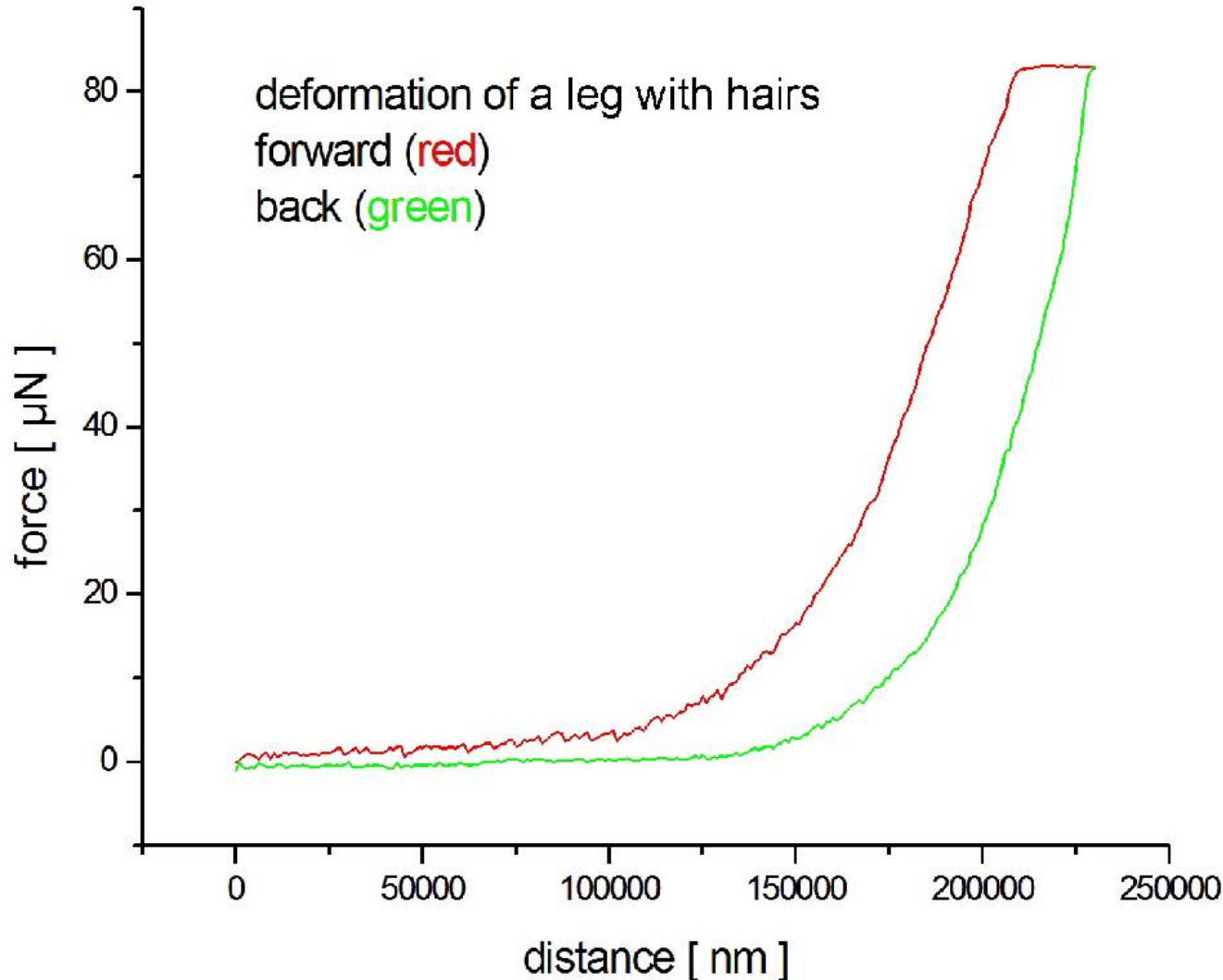
Force Distance Measurements

- The force sensor is moved from the left through hairs against the leg of a fly ...



Live Science Applications

Force Distance Measurements



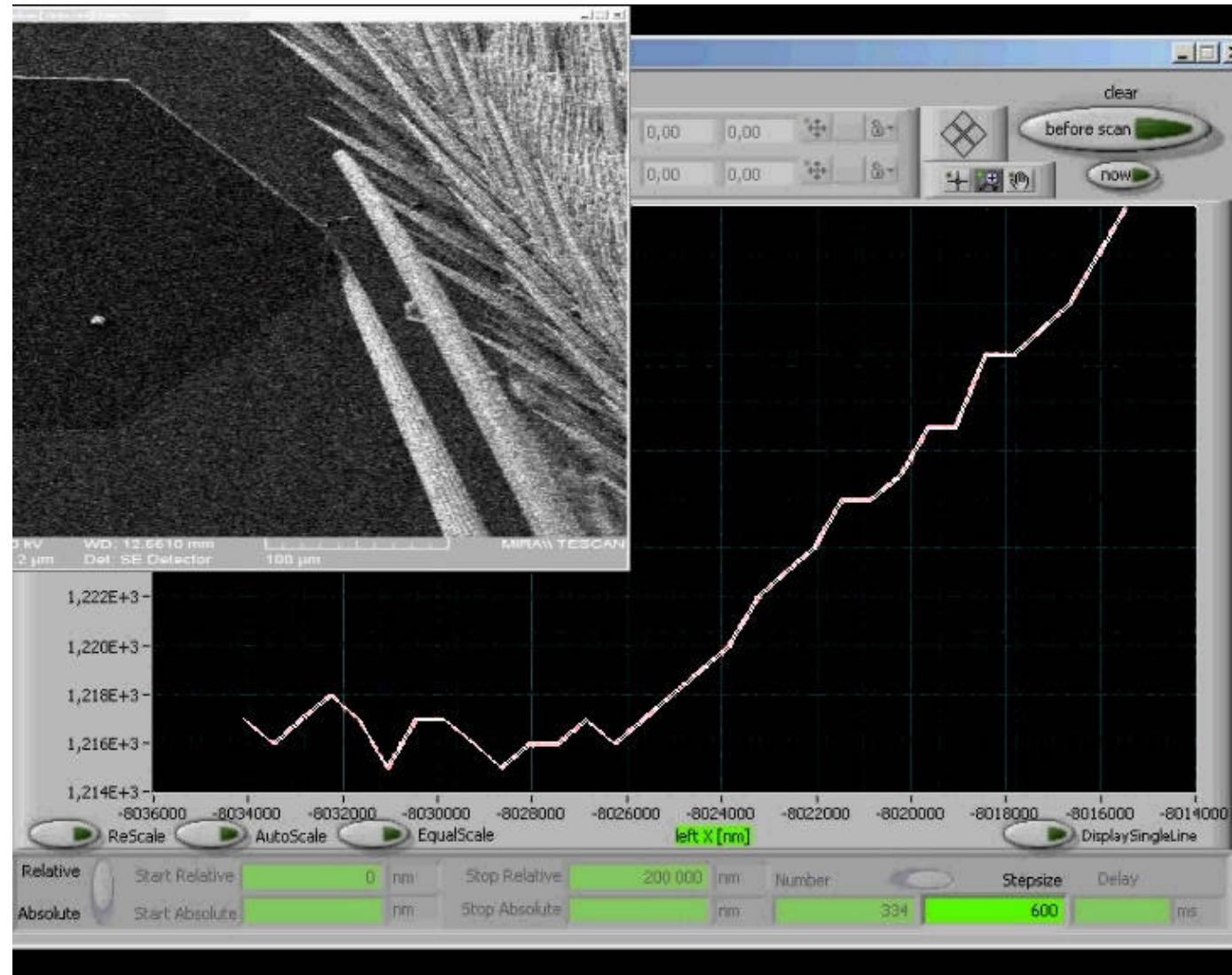
Force – Distance Diagram:

- Single nm resolution in displacement
- Force range depending on used sensor

Live Science Applications

Force Distance Measurements

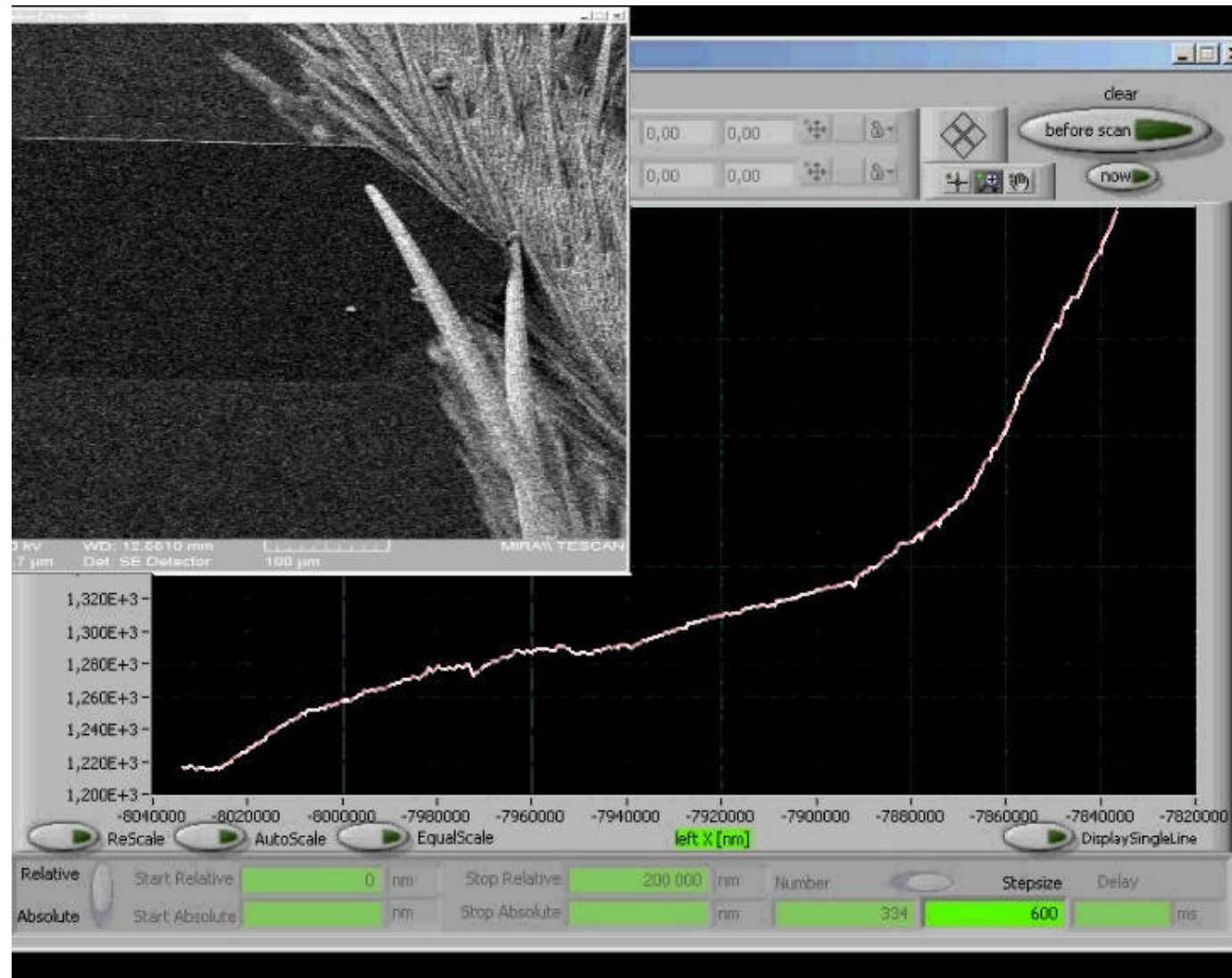
- The force sensor moves against a thick hair
- In the background the force-distance graph is collected



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Force Distance Measurements

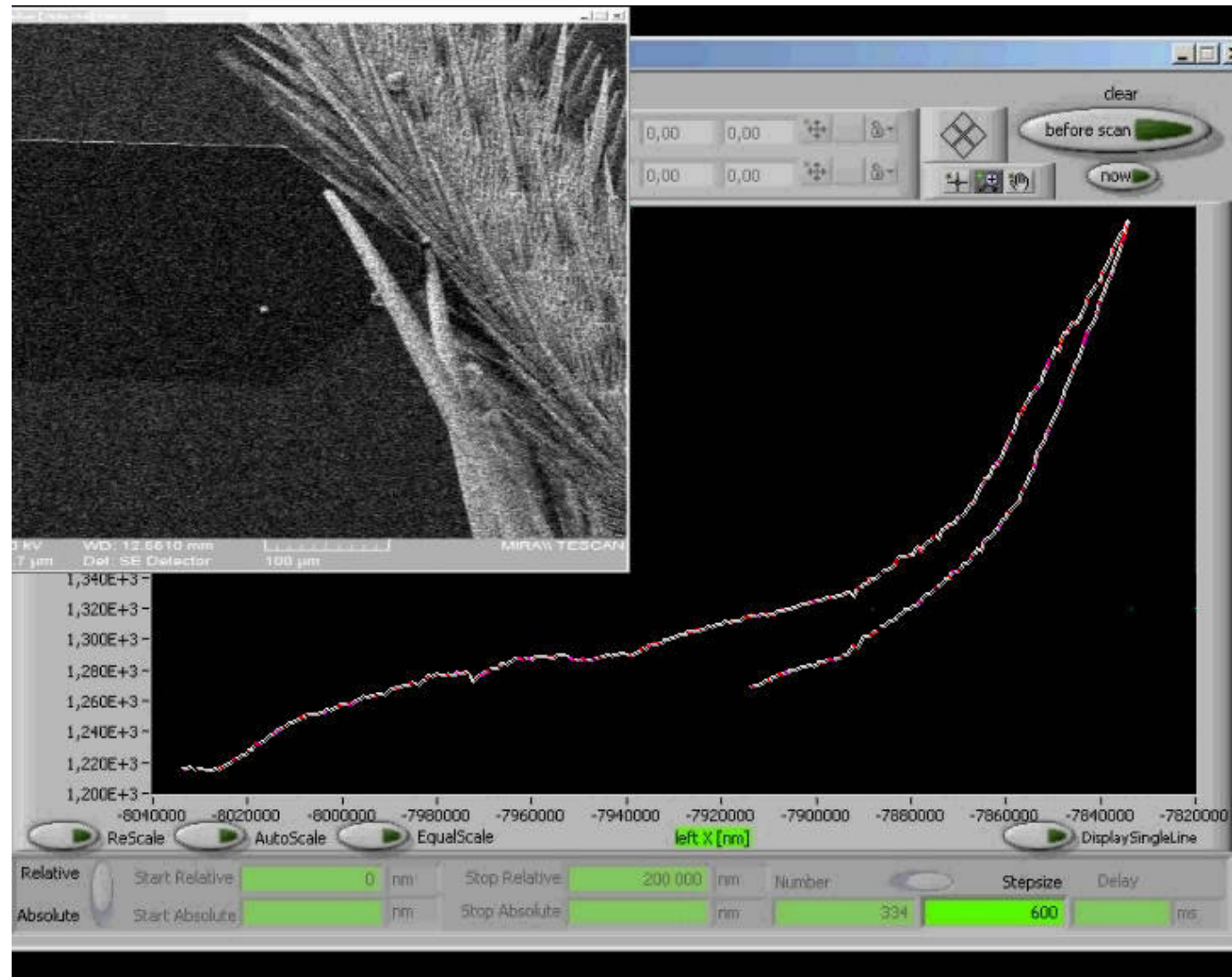
- The force sensor deforms the thick hair and additional the leg (top right)
- In the background the force-distance graph is collected



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Force Distance Measurements

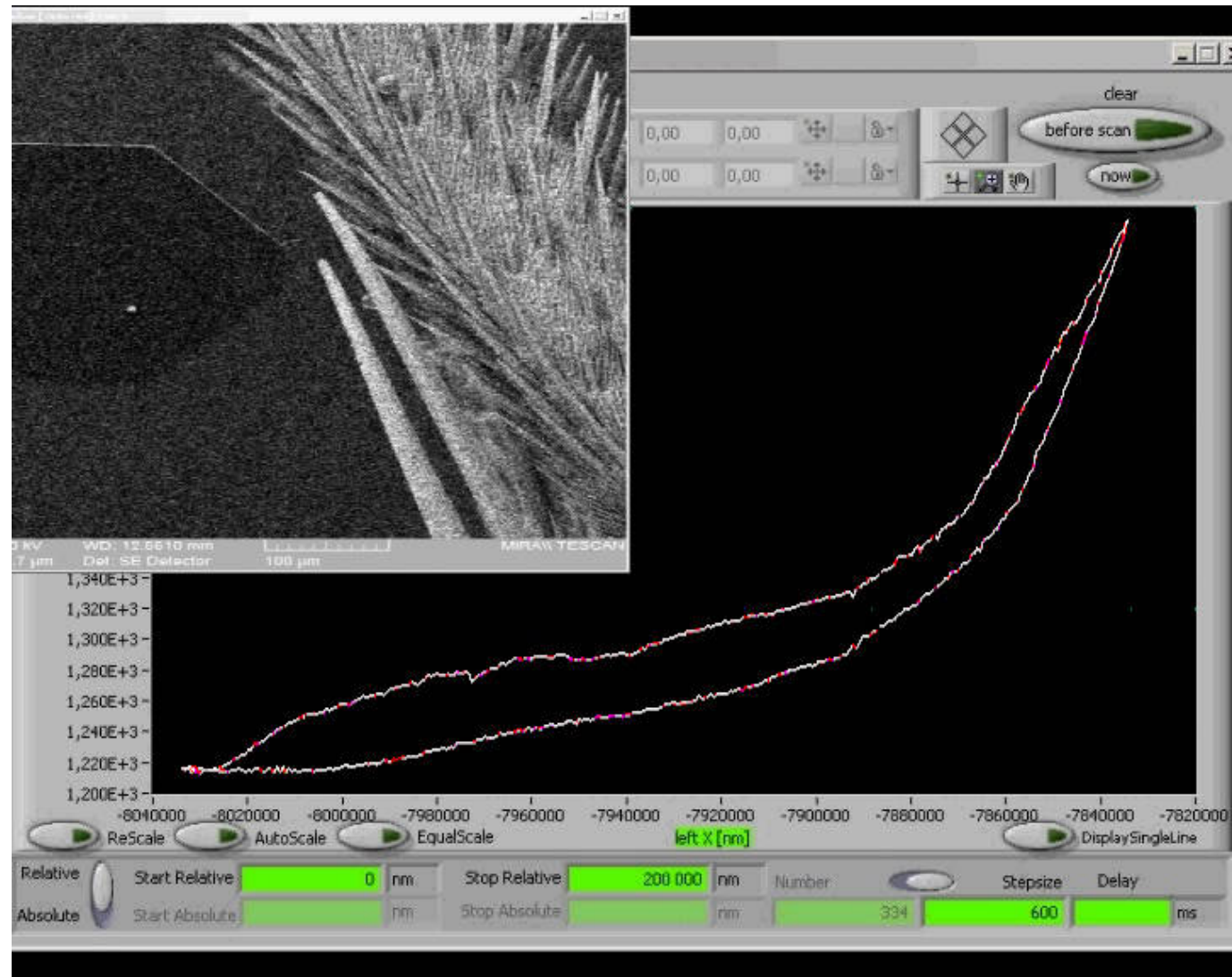
- The force sensor moves back (top left)
- In the background the force-distance graph is collected



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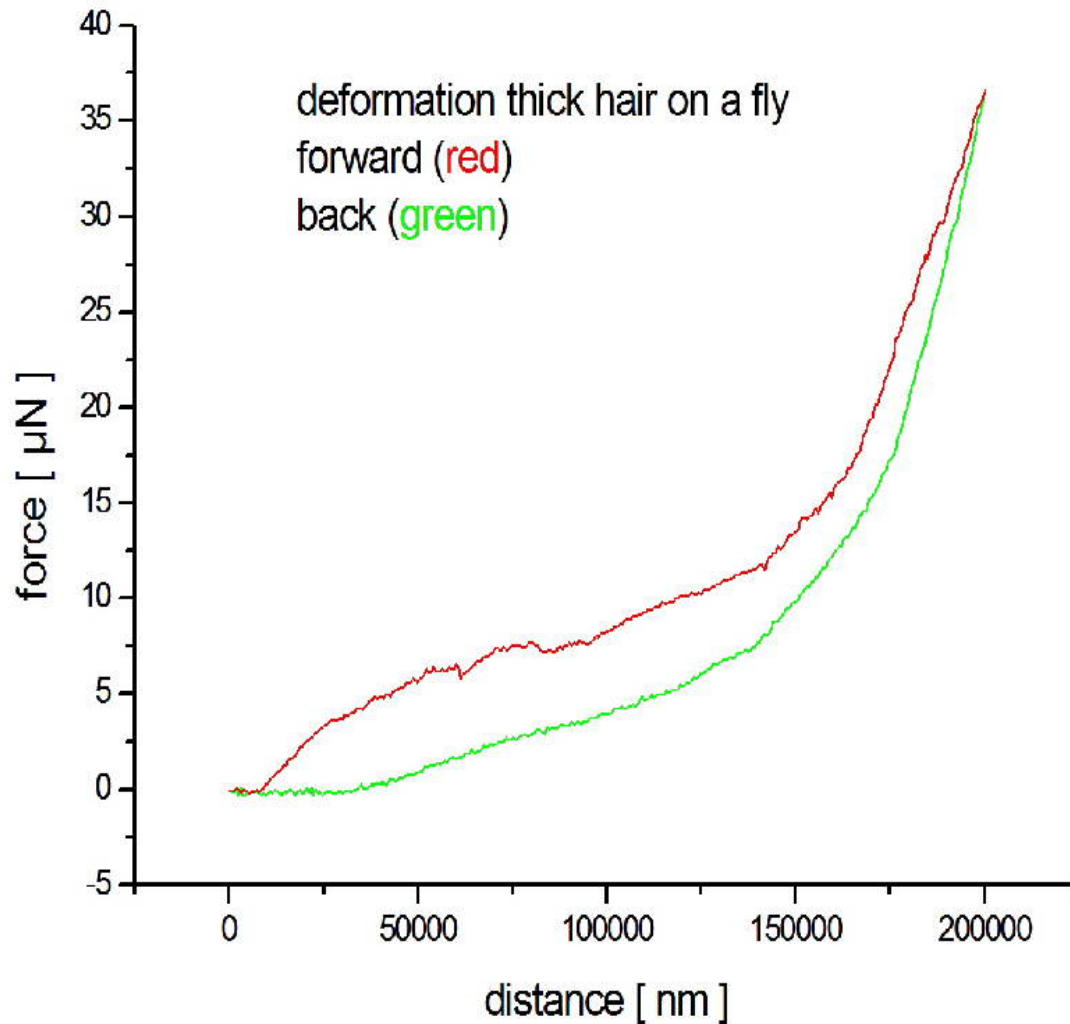
Force Distance Measurements

- Process completed.
- In the background the force-distance graph is collected



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Force Distance Measurements



Force – Distance Diagram:

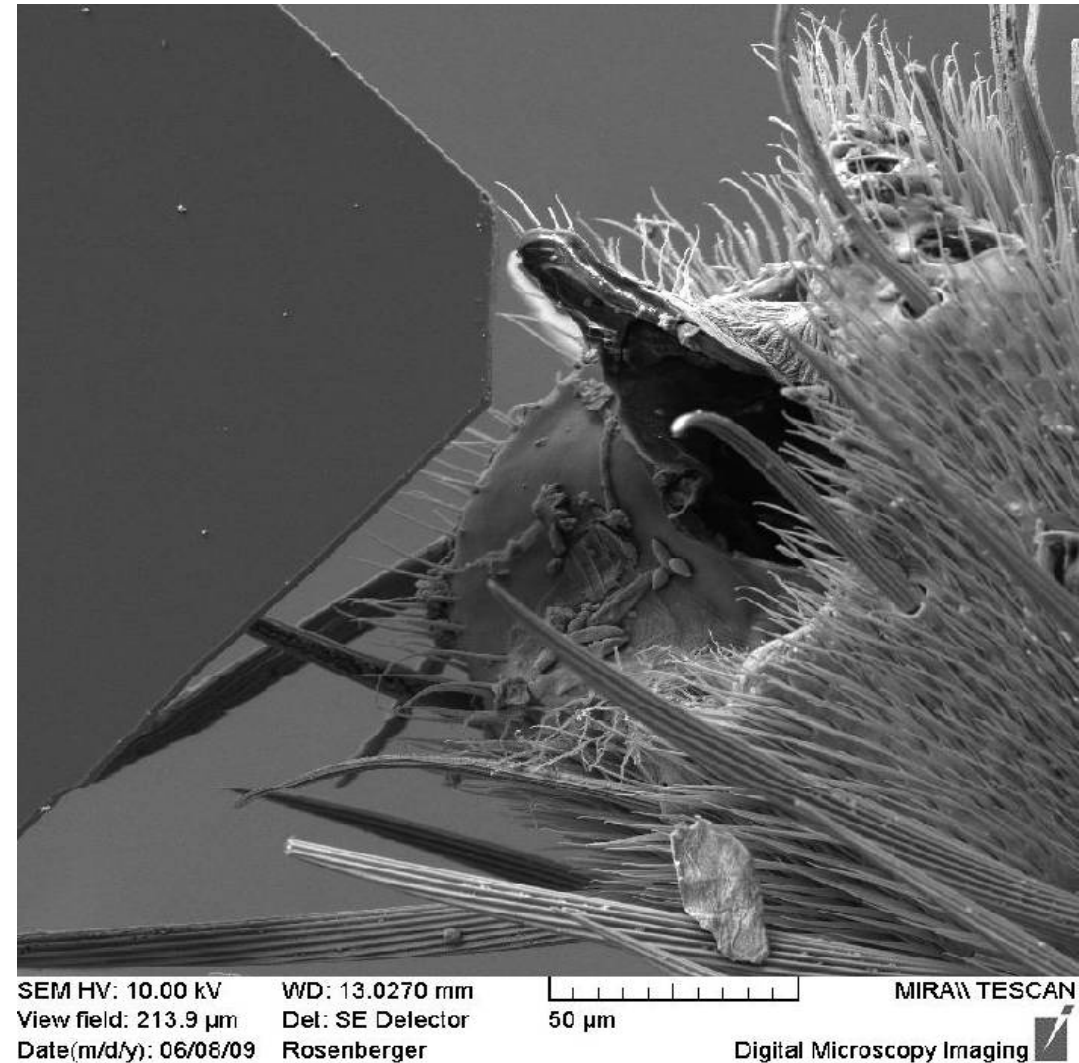
- a thick hair on a fly's leg
- forward direction - red
- back - green

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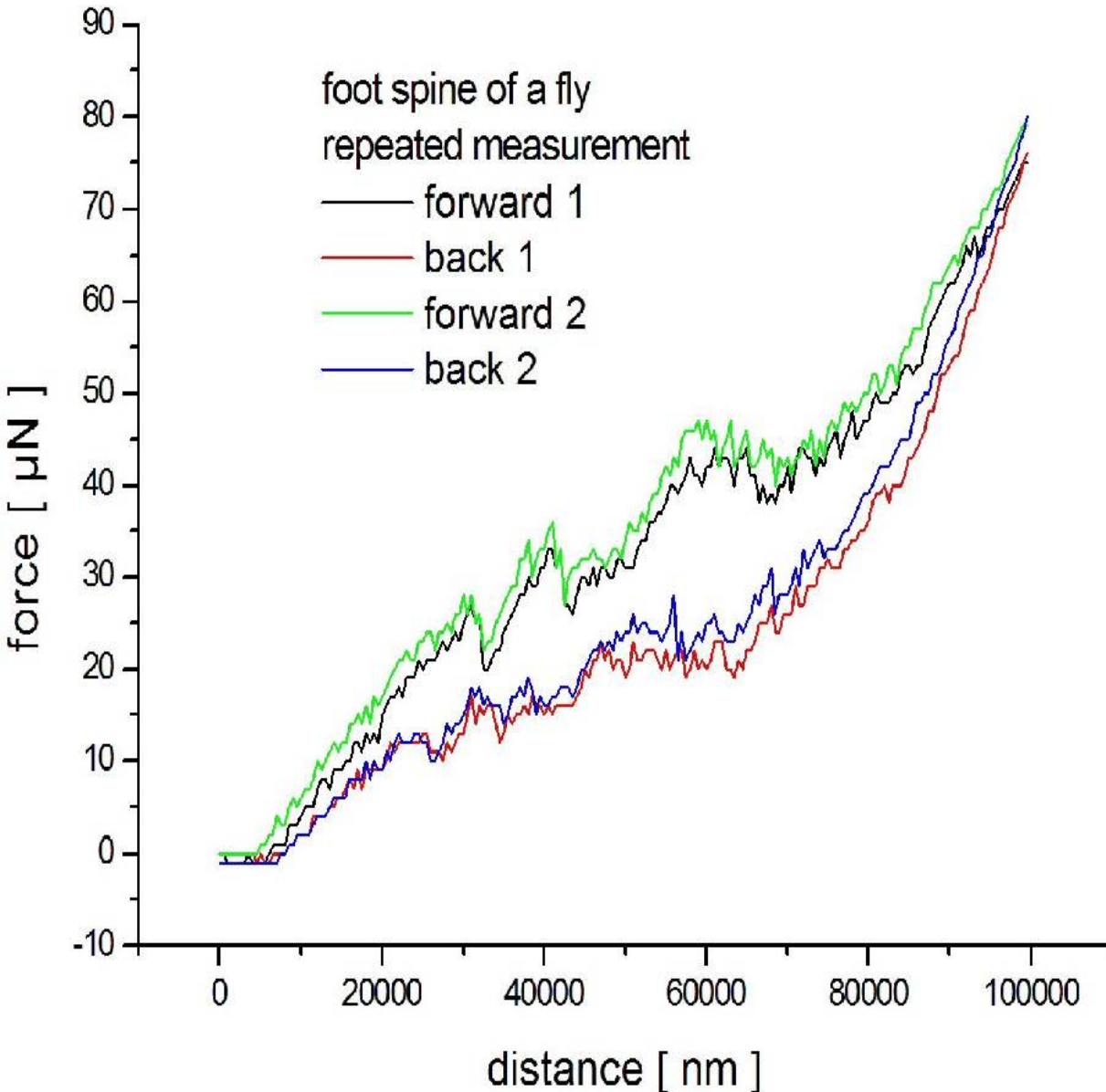
Force Distance Measurements

Force-distance diagram repeatability:

- A force sensor moved by a Nanorobotic manipulator hits a foot spine of a fly and then deforms the whole leg.
- Force and position information are recorded



Live Science Applications



Force Distance Measurements

Force – Distance Diagram Repeatability:

- Deformation of a fly leg
- Measured at the foot spine
- Second measurement shows the repeatability
- First measurement
forward direction – black
back – red
- Second measurement
forward direction – green
back - blue

Summary

- In-SEM/FIB Live Science applications can be realized by Nanorobotic manipulators from Klocke Nanotechnik, equipped e.g. with cutting tools, hooks and microgrippers for sample preparation – and with Force Sensors.
- The Live Image Positioning module allows to direct the tool or sensor in XY to the target area just by mouse-click into the SEM image.
- The automatic approach sensor Nanofinger[®] allows a fast and secure approach of tools to the sample, also on isolators. The sample position can be reported to the other tools (e.g. to a gripper).
- Automation modules and absolute positioning in superior precision allow to program preparation and measurement tasks.

Live Science Applications

Used Products

Products from Klocke Nanotechnik used for this application:

- One High End Nanorobotic Manipulator
- Force measurement system
- Move Until Trigger software module
- Diagram software module
- Force sensors
- Macro Executor
- Live Image Positioning module
- Process Control Sequencer for automation
- Options: Further manipulators with hooks, cutting tools, Nano-Jackhammer module, microgripper, ...