

Processing material in Electron Microscopes...

Working material in several dimensions in an electron microscope becomes possible

The Nanomanipulator from Klocke Nanotechnik extends the electron microscope from an analytical instrument to a material processing system. Through the compact construction of the manipulator a vacuum compatible tool can be inserted into the small space between electron source and sample. No larger than a film cartridge, even several manipulators fit into the vacuum chamber. The manipulator can be moved half a cubic centimeter with a resolution of a millionth of a millimeter.

The manipulator may contain various micro tools for cutting, scraping, gripping, spark erosion and for laser ablation.

The above article was the first choice for the brochure "The Best of TPI, (Technical Press Information) Product News of the HANNOVER FAIR 1999".



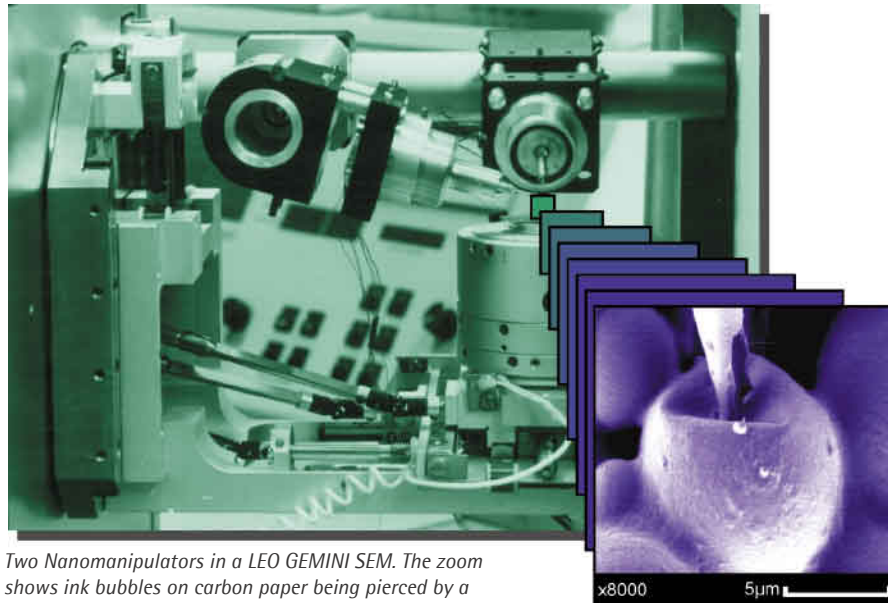
Each Nanomanipulator (seen left, together with a match for scale) consists of a tilting table driven by four Nanomotors for X and Y positioning. A central Nanomotor[®] is used for Z movement pointing upwards or downwards. The tip can be positioned within a volume of 5mm x 5mm x 19mm (Z). The resolution of the Nanomotors that drive the manipulator is in the sub-nanometer range.

The Nanomanipulators can easily be installed in any member of the series of LEO Scanning Electron Microscopes. Within the microscope chamber the Nanomanipulators are mounted on an additional flange on the door, pointing towards the sample stage. If the door is opened the manipulators come out in the same way as the sample stage. First assembling and testing steps can be performed in air, perhaps visualised by a long working distance optical microscope.

After closing the door the combination of Nanomanipulator and SEM leads to a powerful tool as a workbench. It allows micromanipulation in combination with all kinds of analytical methods (EDX, WDX, EBSP).

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Within the variable pressure SEM, even investigations of wet or oily samples in low vacuum or of insulating samples are possible. The picture shows a LEO GEMINI SEM with two Nanomanipulators. The Nanomotor can accommodate sensors or actuators of up to 0.35 mm diameter in its free axial hole. For example this can be a tip (Fig 1), a glass fibre or small bundles of fibres (Fig 2), a hypodermic needle (Fig 3), or a hose (Fig 4). Microsensors or electrically driven actuators (magnetic coils etc.) can be mounted at the end of the carrier tube, the cables are passed through the Nanomotor. Even grippers (Fig 5 & 6) may be mounted within the Nanomotor. They are opened and closed by moving the carrier tube of the Nanomotor. An example of the handling of microparts with two Nanomanipulators is shown in the picture sequence (Fig 7). One micron diameter magnetic beads are exchanged between the tips of two Nanomanipulators by switching from adhesion to magnetism. Two Nanomanipulators open up a wide range of working techniques, comparable to eating with chopsticks. Each Nanomanipulator can be controlled by a single PC card and a joystick. The Nanomanipulator can easily be added to any kind of existing electron microscope that has an unused flange available.



Two Nanomanipulators in a LEO GEMINI SEM. The zoom shows ink bubbles on carbon paper being pierced by a Nanomanipulator with a cannula

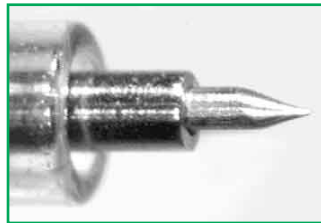


Fig 1: A tip for scratching or spark erosion



Fig 2: A glass fibre or small bundles of fibres



Fig 3: A hypodermic needle



Fig 4: A hose

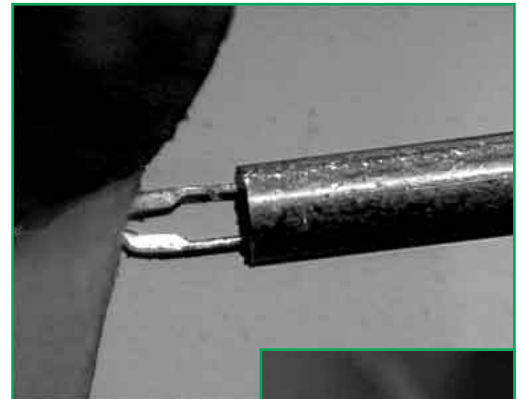


Fig 5 & 6: Even grippers may be mounted within the Nanomotor. They are opened and closed by moving the carrier tube of the Nanomotor



Fig 7: Exchange of 1 μm diameter magnetic beads between two Nanomanipulators

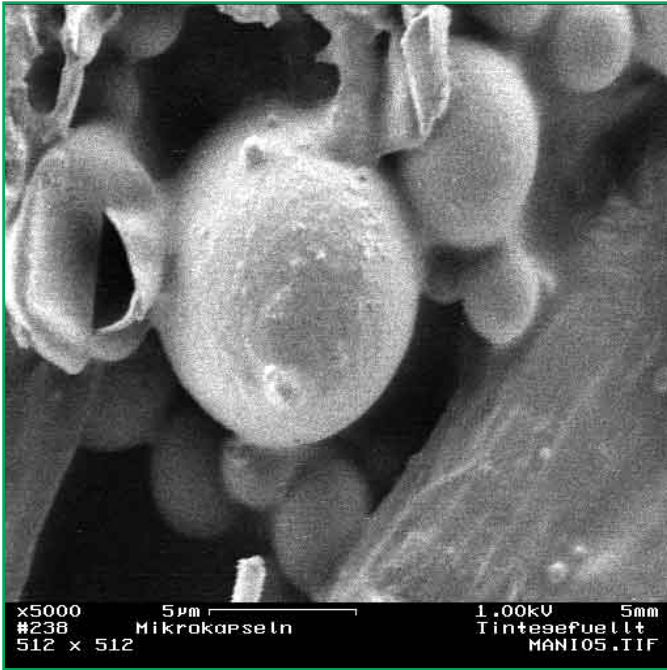


Fig 8: A needle or cannula as a tool

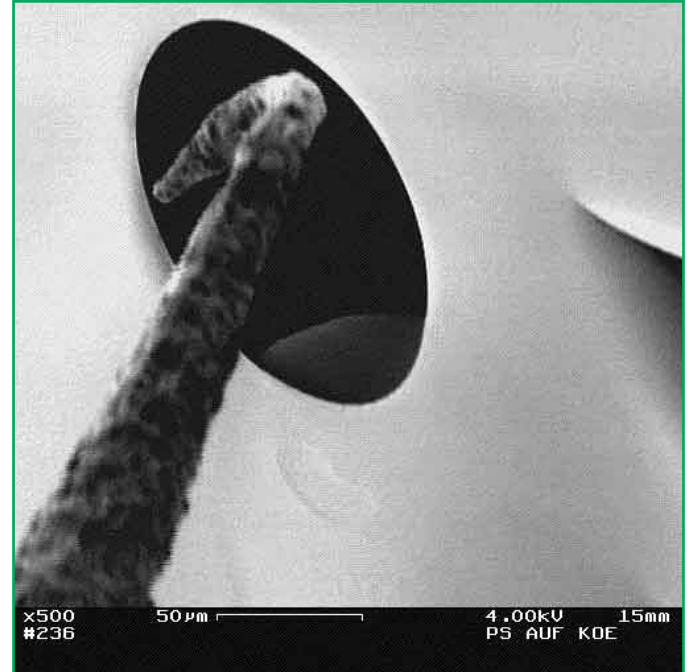


Fig 9: A hook to pull at the material

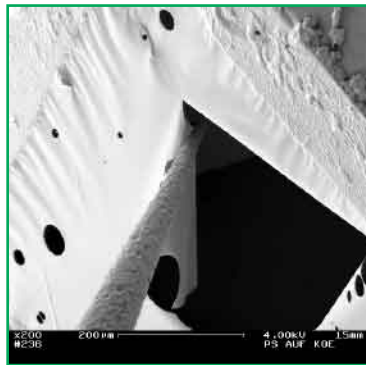


Fig 10: The Hook moving a foil aside

Fig 9 & 10: The Hook

More complex is the movement of a hook to move behind something, grab it and pull it away.

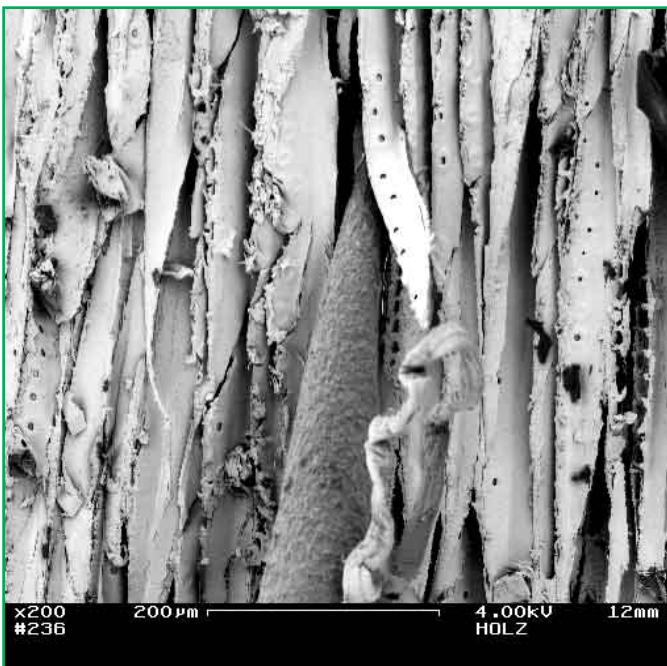


Fig 11: The axe or crowbar to chip wood

Fig 11: Axe or crowbar to chip material

Even wood can be chipped with the Nanomanipulator. This example is similar to problems common in pharmaceutical development: detaching small pieces of frozen human skin. A similar problem could be solved for a customer concerning electroplating. The customer laminates 0.3 µm small palladium spheres onto a thick copper film and wanted to know, if they were rigidly joined with the copper film. With a magnification of 20kx the palladium spheres were pushed with the tip of the Nanomanipulator. It was only possible to remove them from the substrate together with the thick copper film. This quick and easy experiment proved that the palladium spheres are more tightly bound with the copper film than the copper film with the substrate. The customer could not find this answer by any other technology.

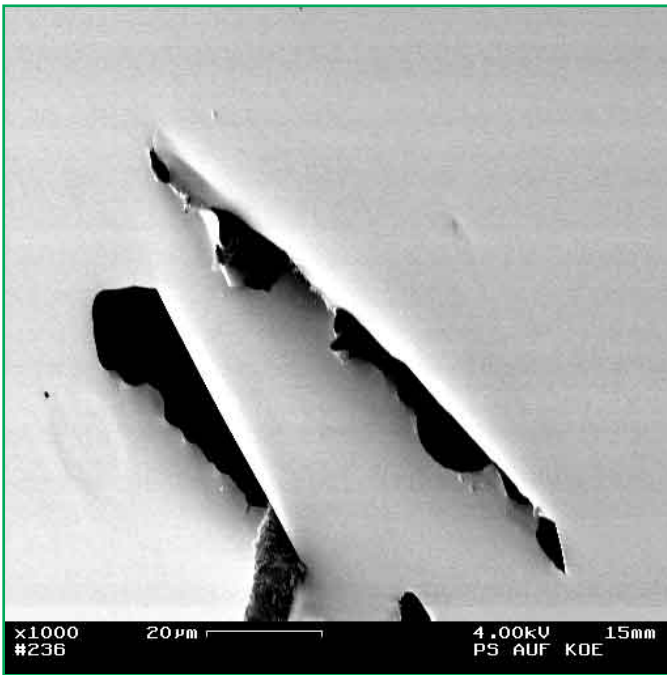


Fig 12: A knife for cutting material is another important tool

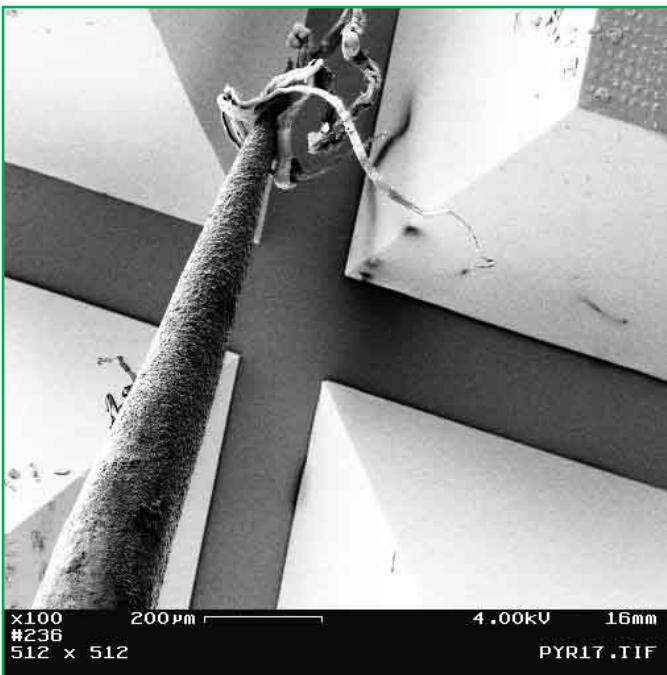


Fig 13: A cleaner removing dust from a chip

The examples illustrated were prepared by using two Nanomanipulators in a LEO SEM:

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For further information on this paper please contact the above or visit website: <http://www.nanomotor.de>

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