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NANOHANDLING AND MANIPULATION OF BIOLOGICAL SPECIMEN BY ATOMIC-FORCE MICROSCOPY

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INTRODUCTION: Micromanipulation techniques are valuable tools for the extraction and local structuring of smallest amounts of biological material[1,2]. Modern applications in biological research require high-resolution methods allowing the manipulation of biological samples with a precision beyond the resolution limit of light microscopy. For this purpose the atomic force microscope (AFM) is an appropriate tool. In order to enable precise sample manipulation an intuitive user interface is required together with as-fast-as-possible[3] nano-positioning capabilities of the instrument.

METHODS: A simple but intuitive human machine interface was realized by coupling a standard force feedback joystick to an AFM with integrated UV micro laser beam unit. Human metaphase chromosomes were dissected with the aid of this direct force feedback during sample manipulation. For mechanical AFM manipulation the loading force was increased, UV micro laser beam dissection was performed with a pulse repetition rate of 60 Hz and a pulse energy of 0.7 µJ at the sample with a scan speed of 0.3 µm/s.

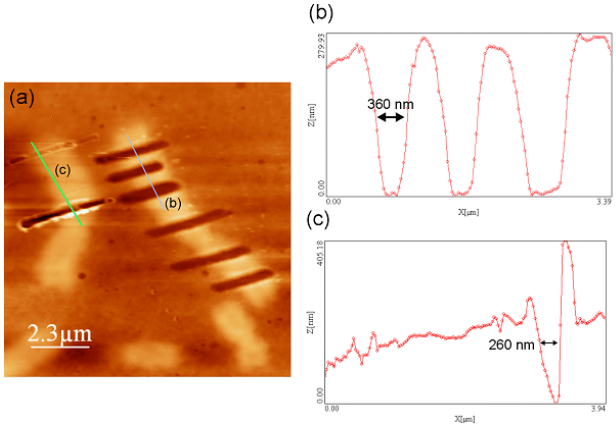

Fig. 1:(a) Topographic AFM images of human metaphase chromosomes dissected by AFM and UV-laser micro dissection. Cross section through (b) laser and (c) AFM cut chromosomes.

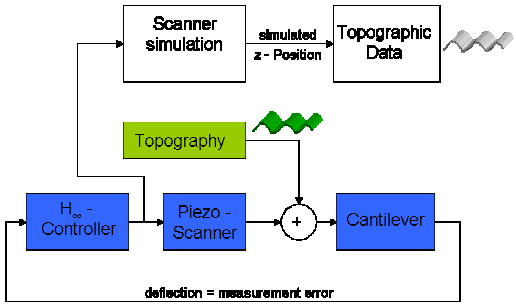

Fig. 2: Scheme of the control circuit for high-speed scanning AFM.

RESULTS & DISCUSSION: In the topographic AFM image (Fig. 1 a) the different cuts can be distinguished and analysed. The chromosome marked (b) was dissected with the UV-laser. A minimum cut width (full width at half maximum cut depth) of 360 nm could be achieved.

Different cut depths could be realized by AFM. At a loading force of 10 µN of the tip onto the sample, a minute scratch with a cut depth of 20 nm and a cut width of 50 nm could be realized. At the side of the cuts biological material was deposited by the ploughing tip.

CONCLUSIONS: A high-speed mode that is realized by applying modern model-based control methods to the AFM will be implemented into a manipulation instrument (Fig. 2). The combination of both technical features will simplify and speed up nanostructuring of biological surfaces.

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