

Functional Materials with Shape Memory Effect at Nanoscale of Dimensions

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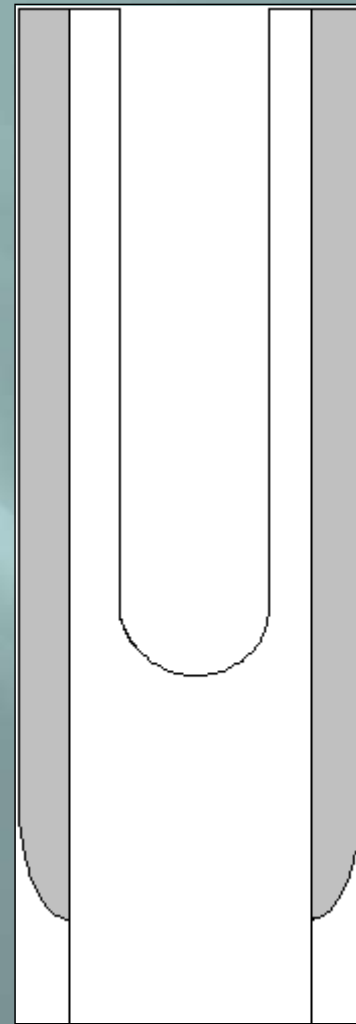
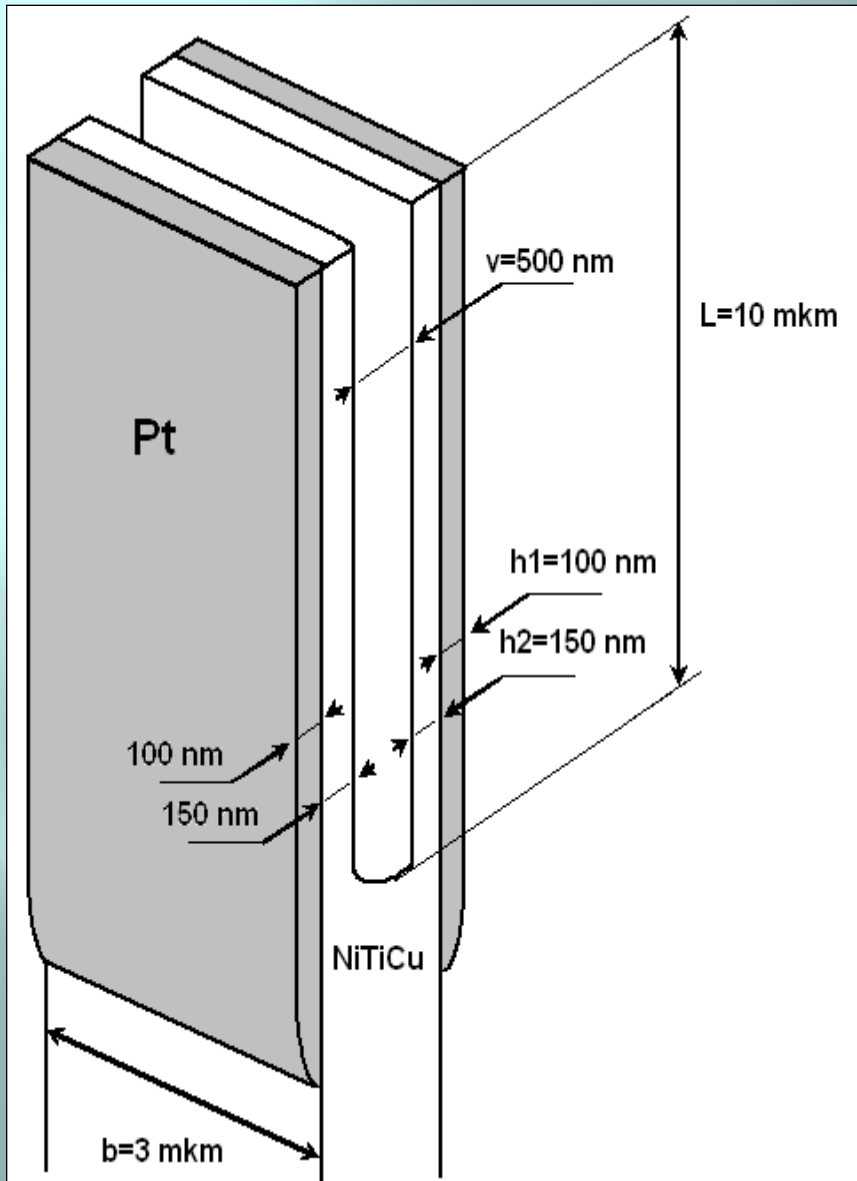
in collaboration with:

National Research Nuclear University "MEPhI", Moscow

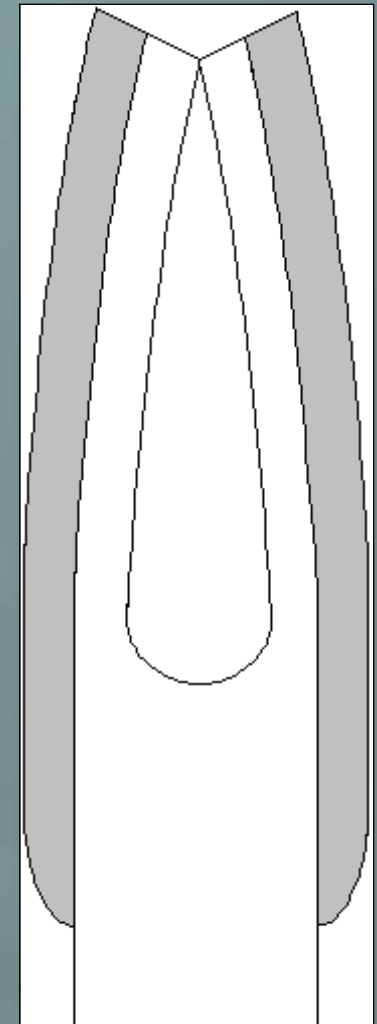
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Saint-Petersburg***



Nanotweezers project



$$T < T_m$$

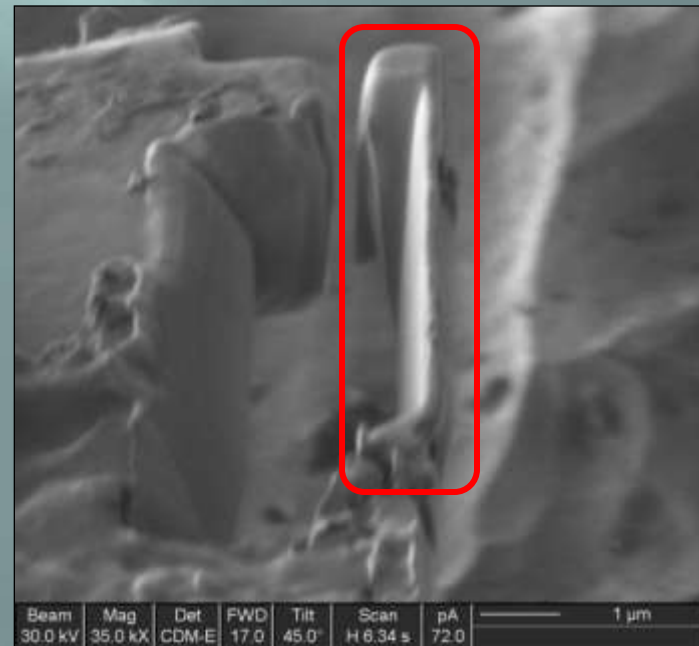
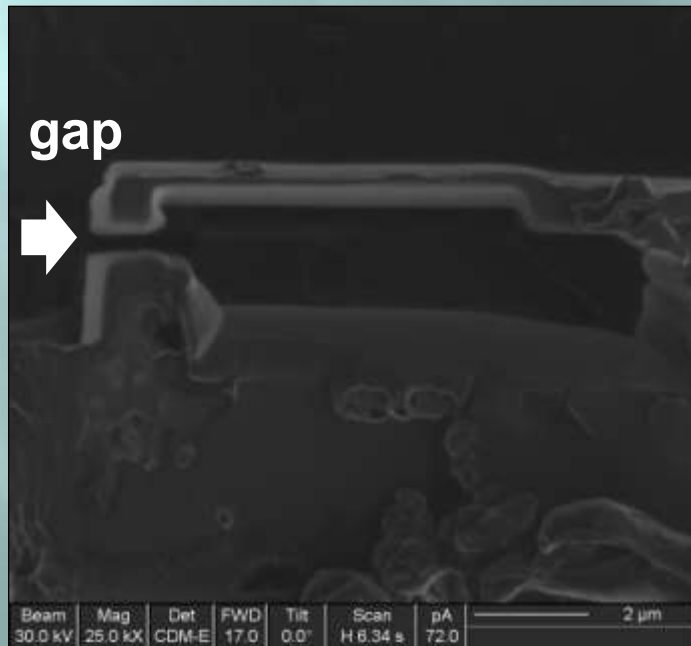
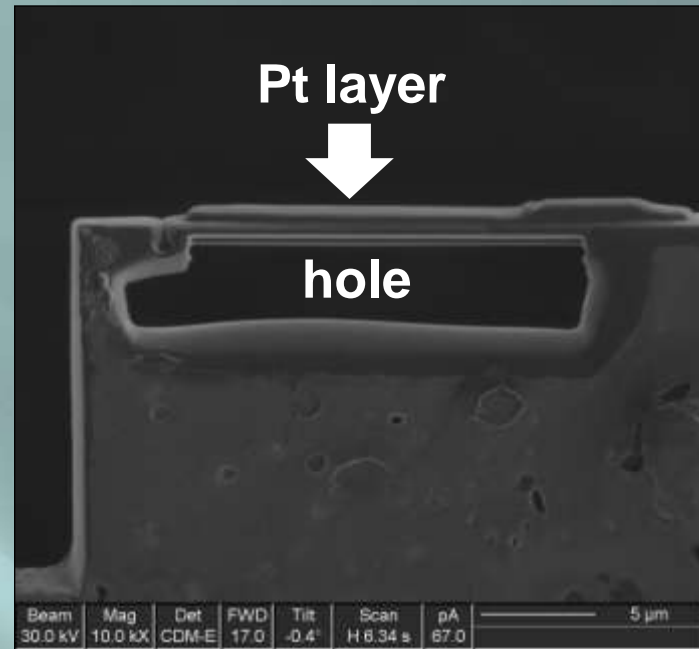
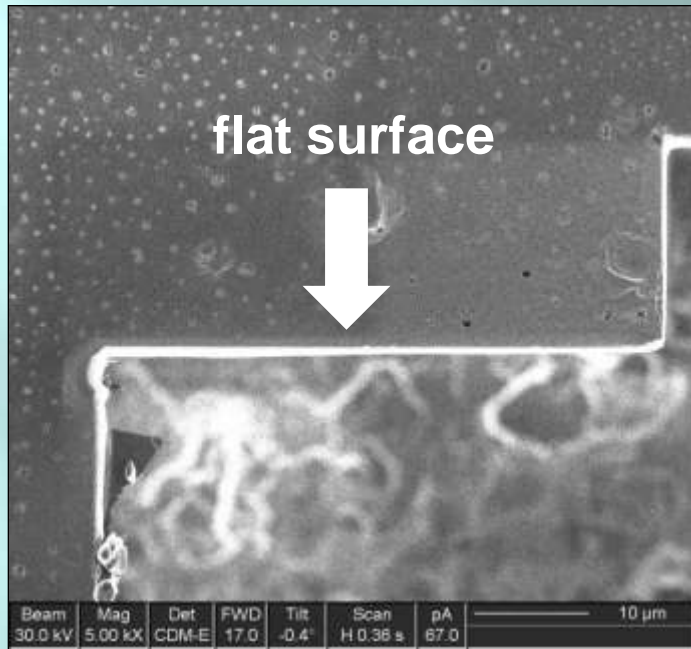


$$T > T_m$$

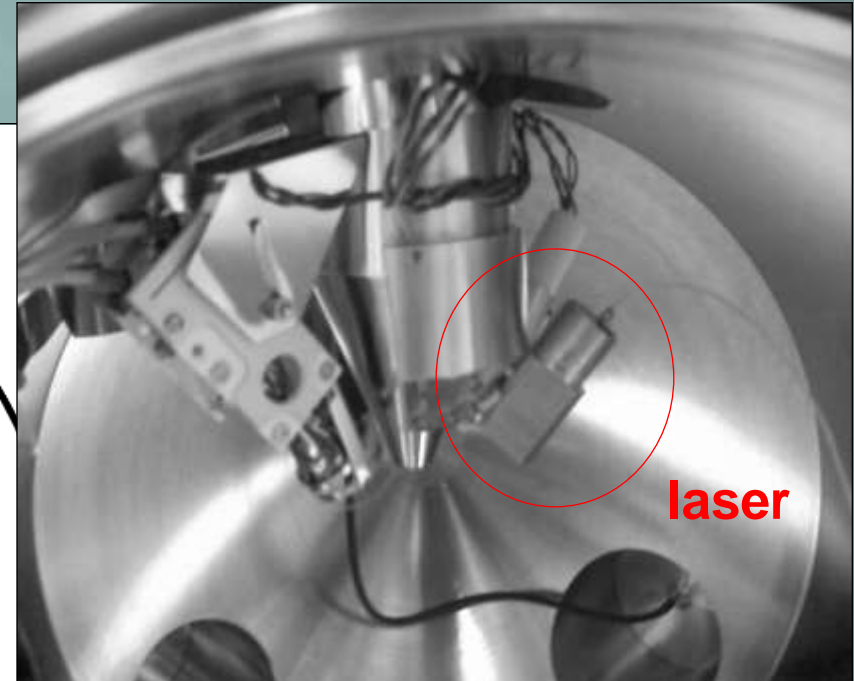
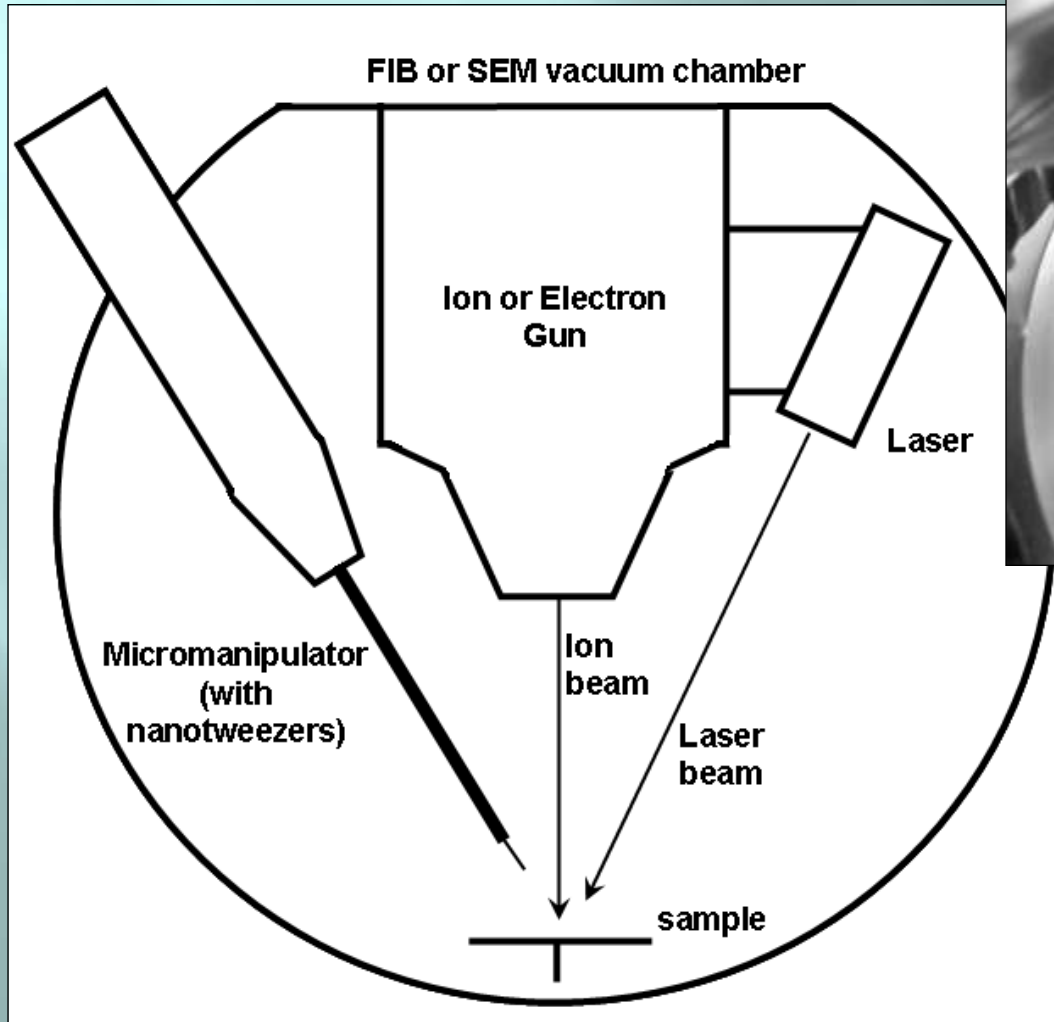
Advantages of the scheme:

- **Giant relative deformations: 1 - 10 %.** Thus record small dimensions are enough for manipulation.
- **Simple manufacturing techniques: standard processes.**
- **Possibility to make a submicron size actuator, thus the size of grasped object will be down to 10 nm.**
- **Possibility to supplement the standard micromanipulators, like Kleindiek® or Omniprobe®.**
- **Convenient work temperature range : 40 - 60 °C.**

Fabricating the nanotweezers by FIB

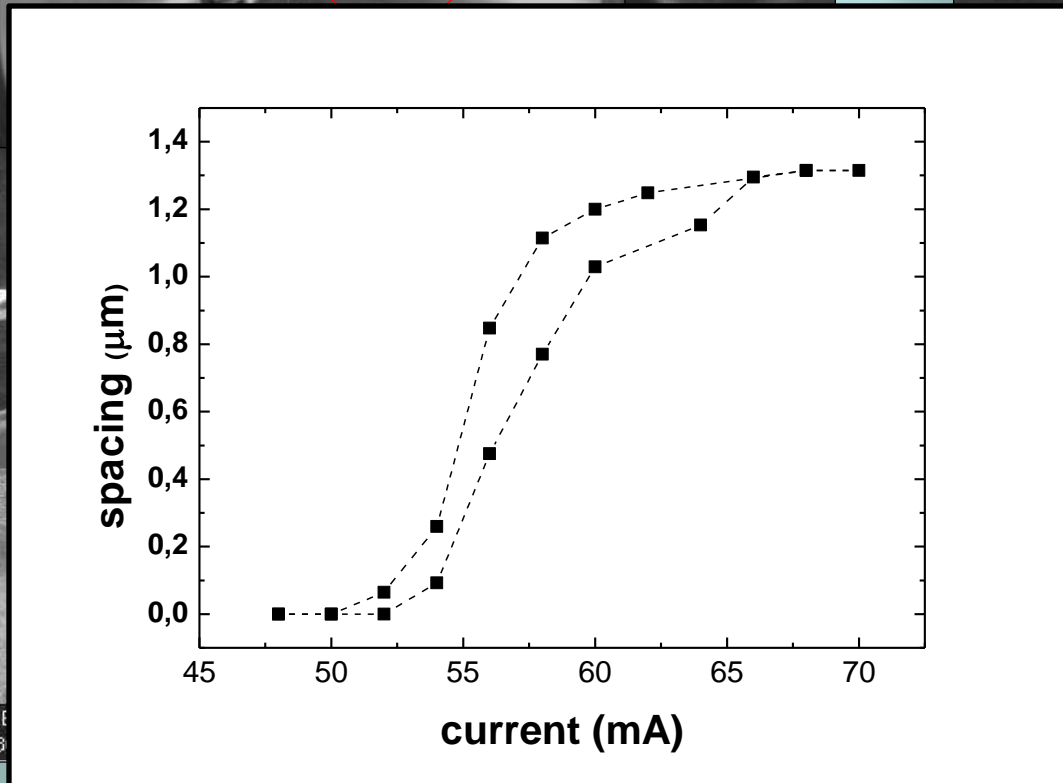
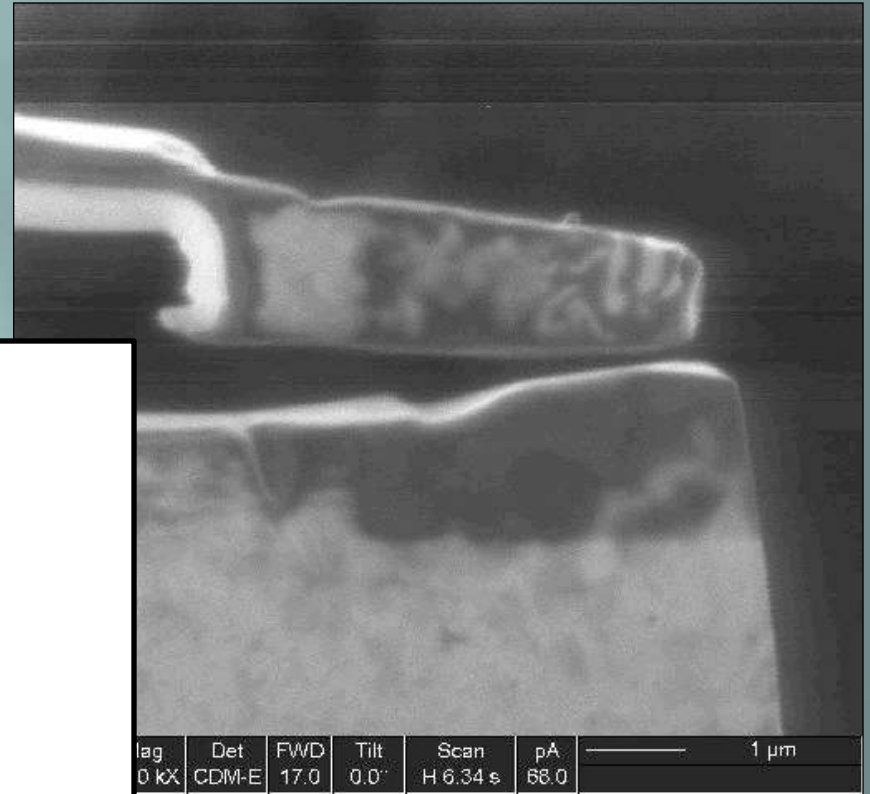
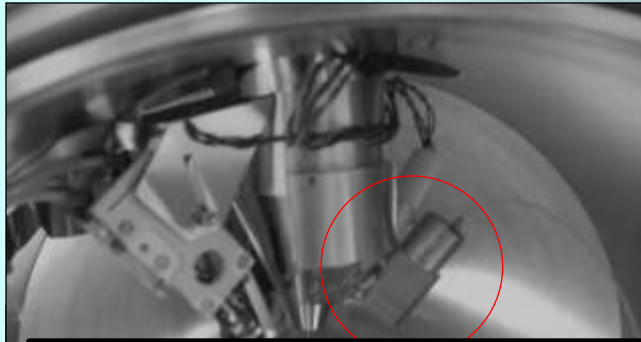


Heating control of nanotweezers by semiconductor laser in FIB vacuum chamber



Nanotweezers prototype made by FIB

Control system integrated in the vacuum chamber



dimensions 12x3x1 microns

grasped objects < 1200 nm

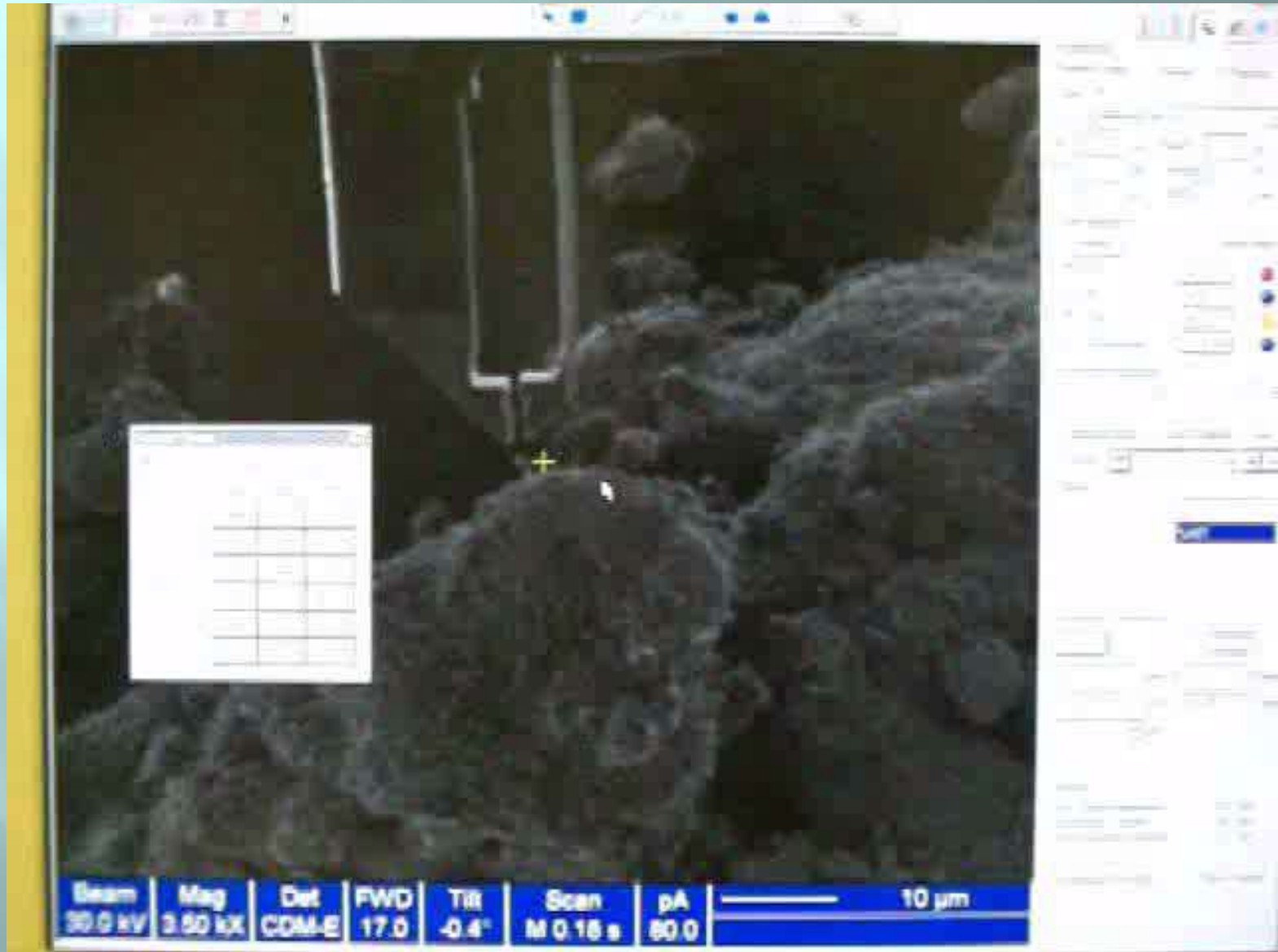
smwsm.org//II/micropincer.html

Switching time of Nanotweezers prototype

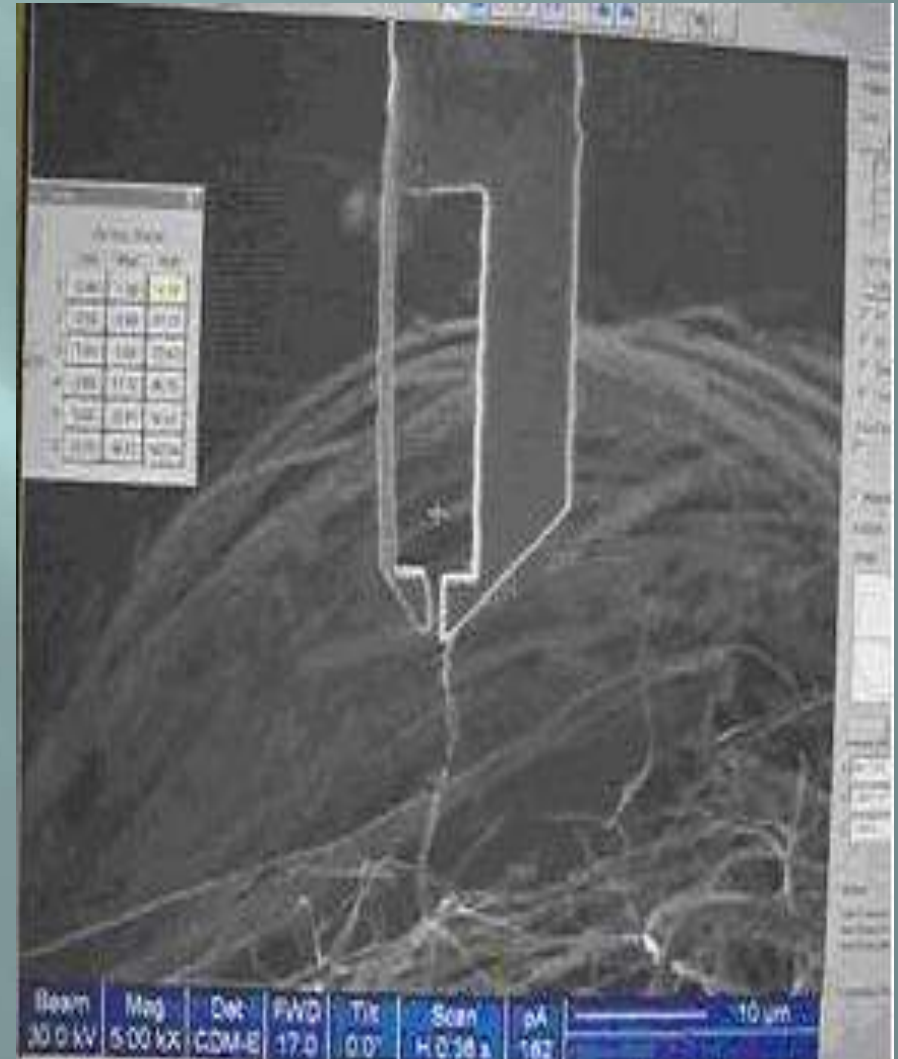
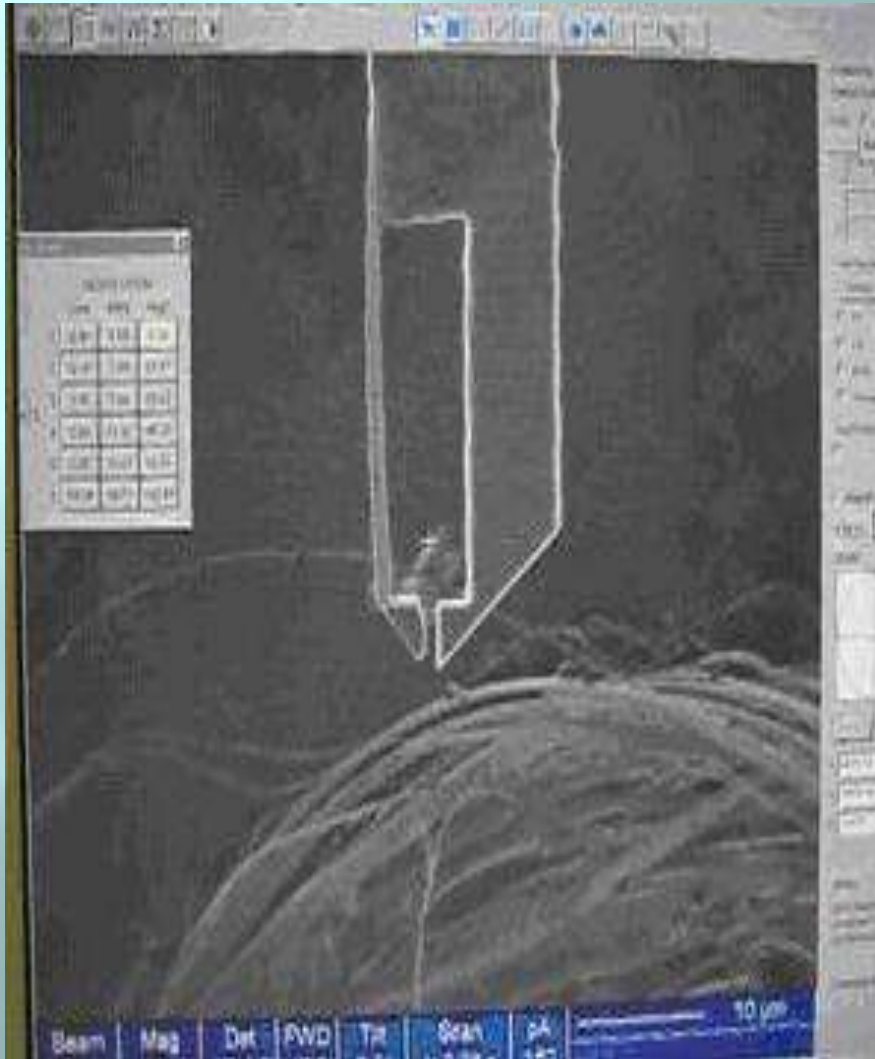


Time of switching ~ 200 ms

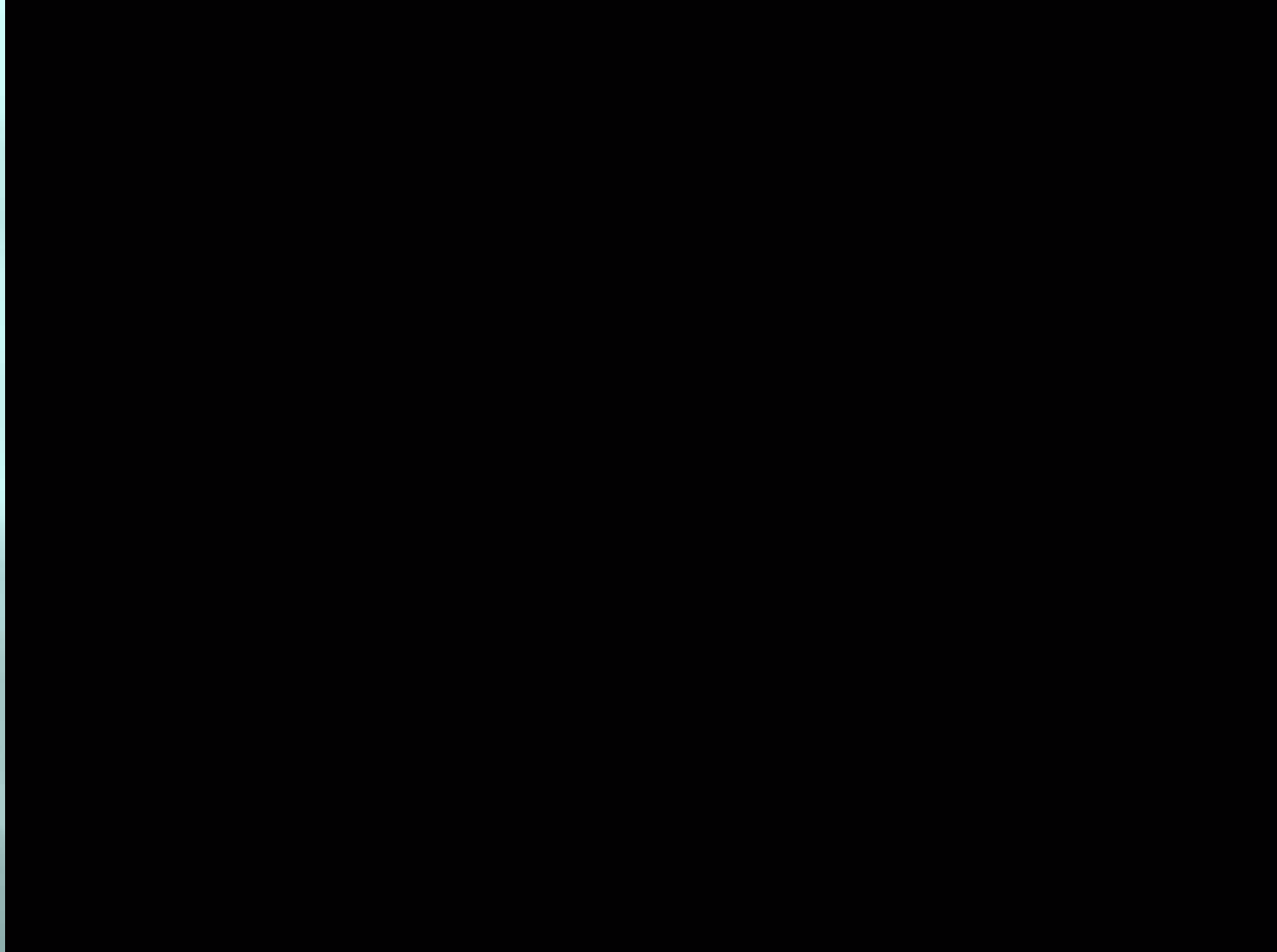
Manipulation with CNT sample



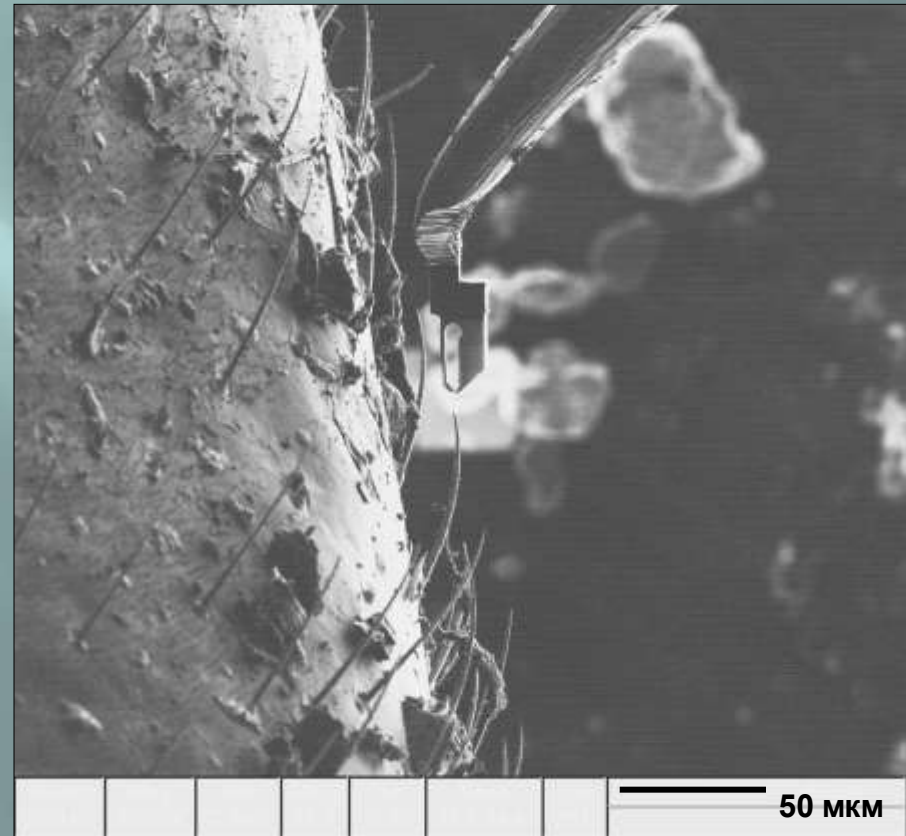
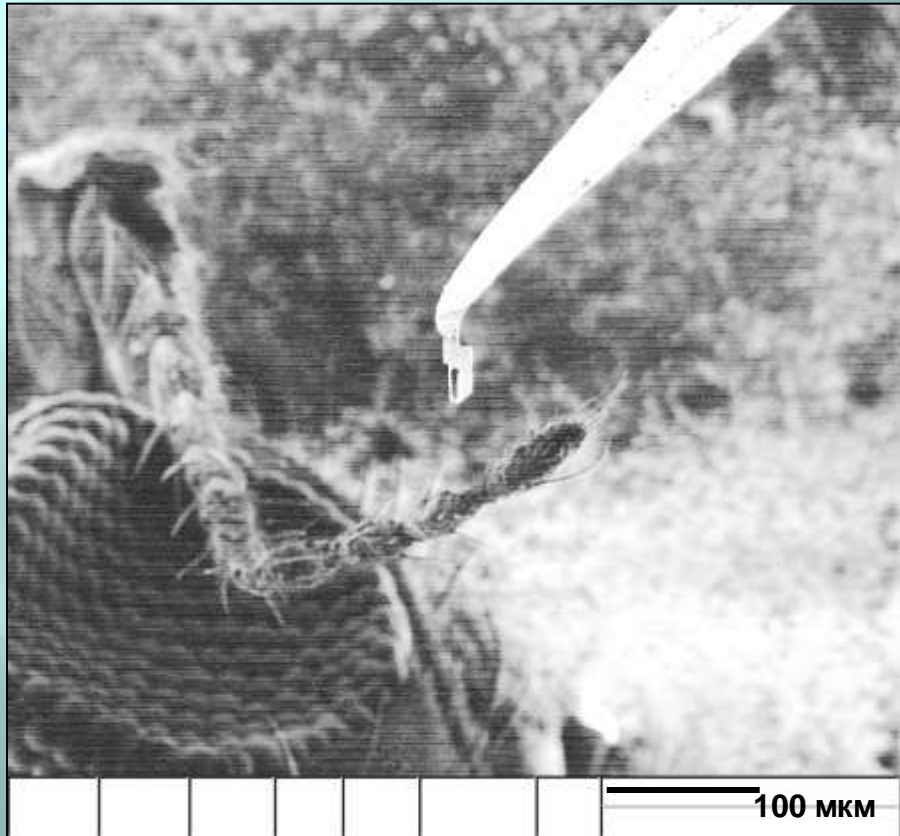
Manipulation with Ta₃S whiskers



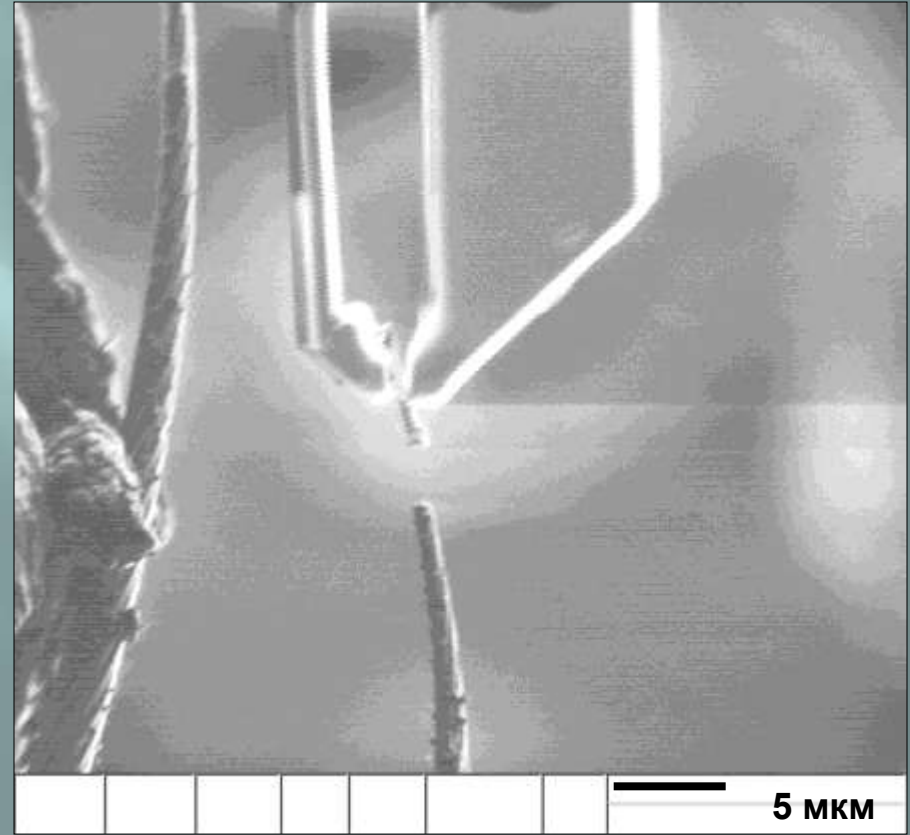
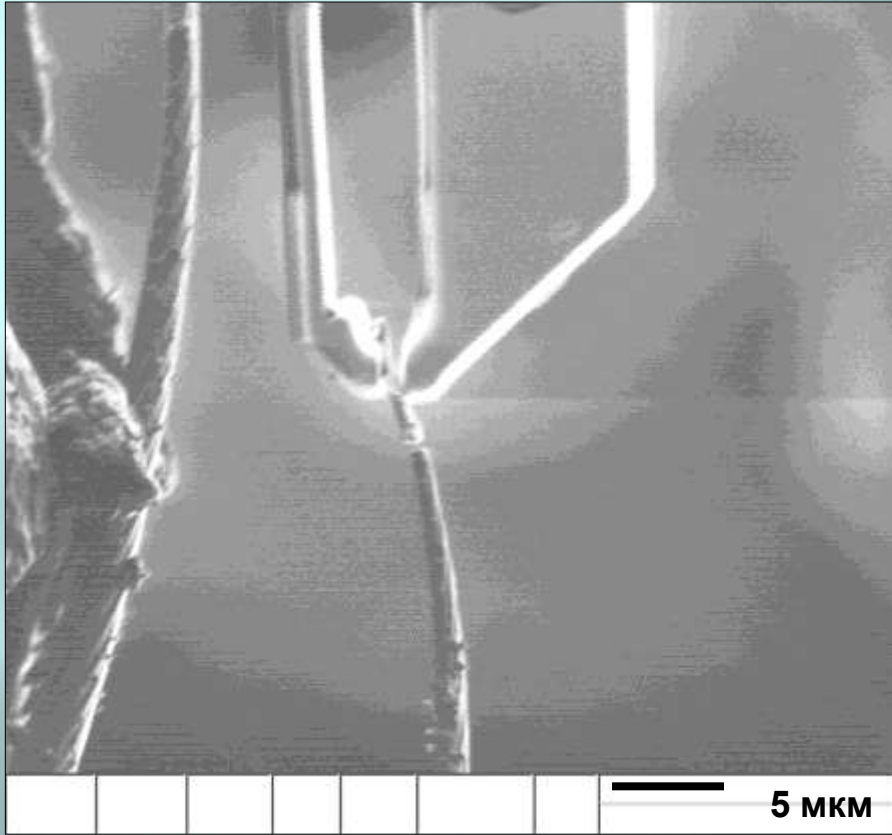
Manipulation with biological microobject. Part of *Culex pipiens*



Manipulation with biological microobject. Part of *Culex pipiens*



Manipulation with biological microobject. Part of *Culex pipiens*



Manipulation with biological microobject. Part of *Culex pipiens*



Conclusion

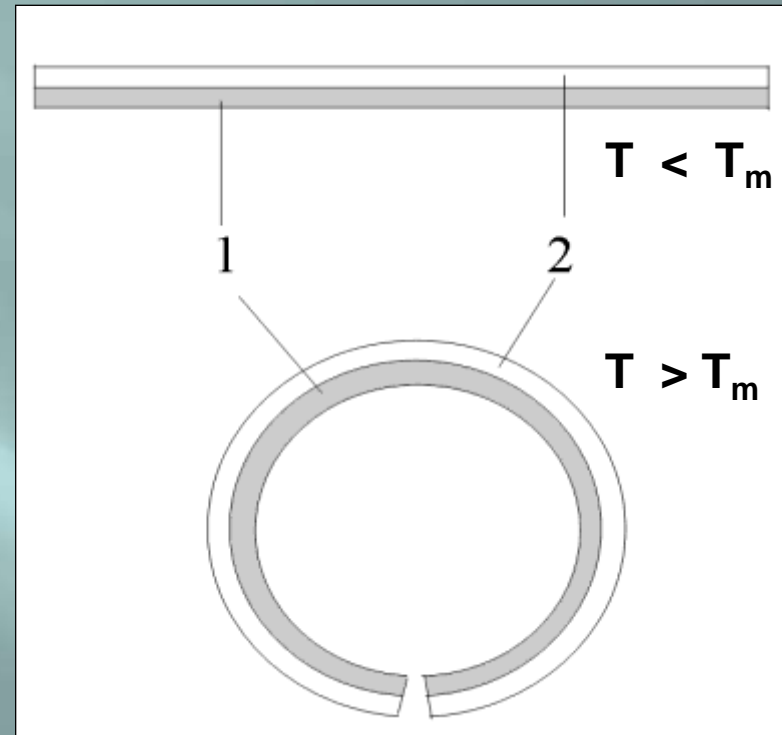
- **The prototypes of nanotweezers were created by Focused Ion Beam technique. The control is carried out by a beam of semiconductor laser in the environment of scanning electron/ion microscope. The smallest overall dimensions of the nanotweezers are 1x1x0,14 μm .**
- **Reversible bending strain of up to 1 % was observed on micron and submicron scale for fabricated composites.**
- **The proposed scheme can be applied in designing of other types of nano-instruments for micro- and nanotechnology, microbiology and microsurgery.**

We are currently developing a nano-instrument system for capturing, moving and storing the micro- and nano-objects.

Action principle of new composite actuator

1. shape memory layer
2. elastic layer

SME: giant pseudoplastic deformation up to 10 %

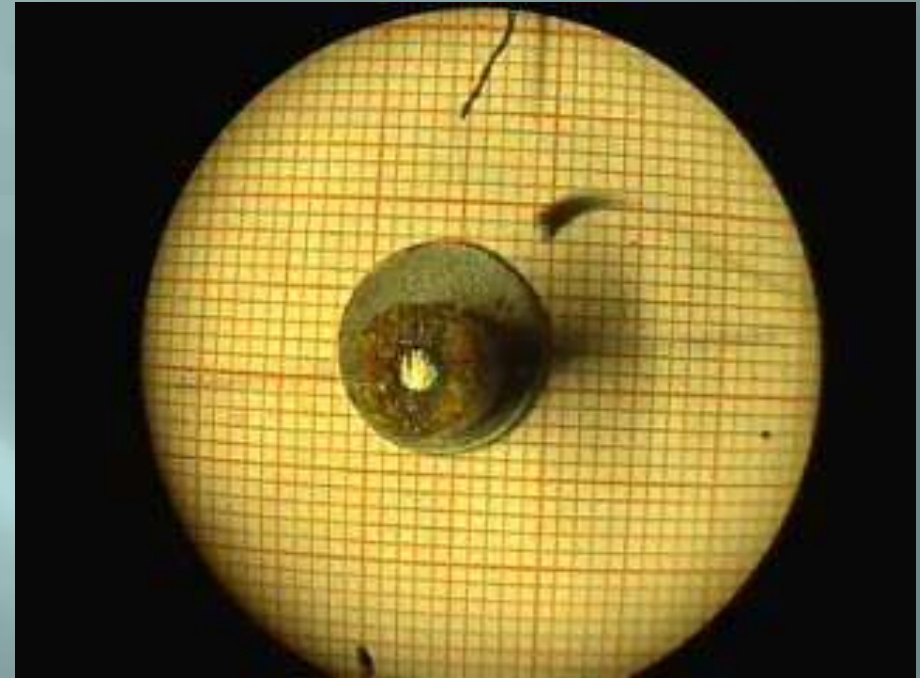


The result is the *reversible giant bending strain (up to 10 %)* of composite, using only “one-way shape memory” effect.

Bending deformation is *2-3 orders higher* than in a usual bimetallic plate.

The control can be carried out by a thermal field or by magnetic field (for ferromagnetic alloys).

Model of new composite actuator



**Shape memory composite
controlled by uniform heating**

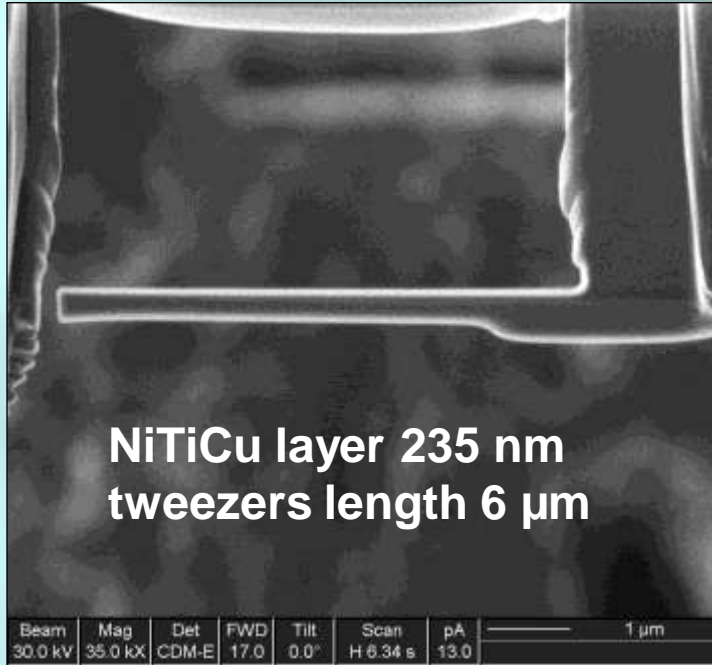
**30 μm NiTiCu / 30 μm steel
(gluing)**

“Spider leg” manipulator

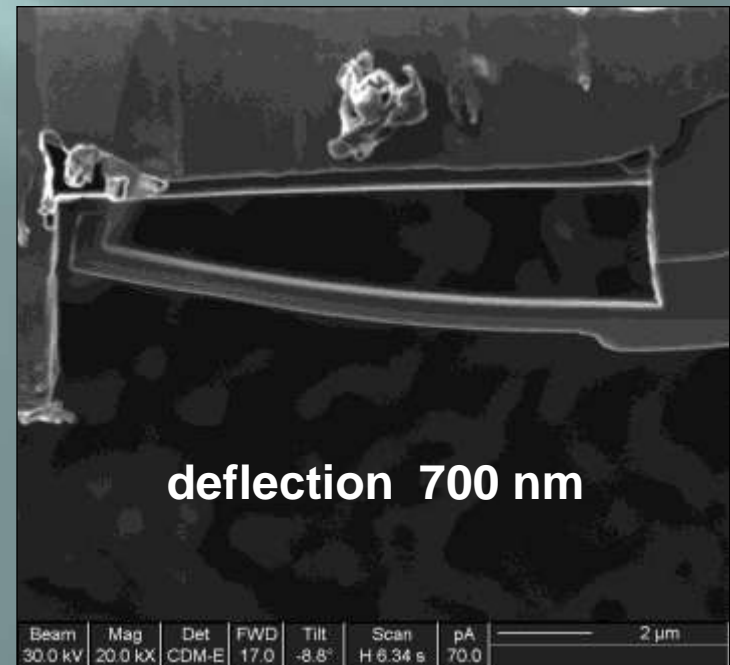
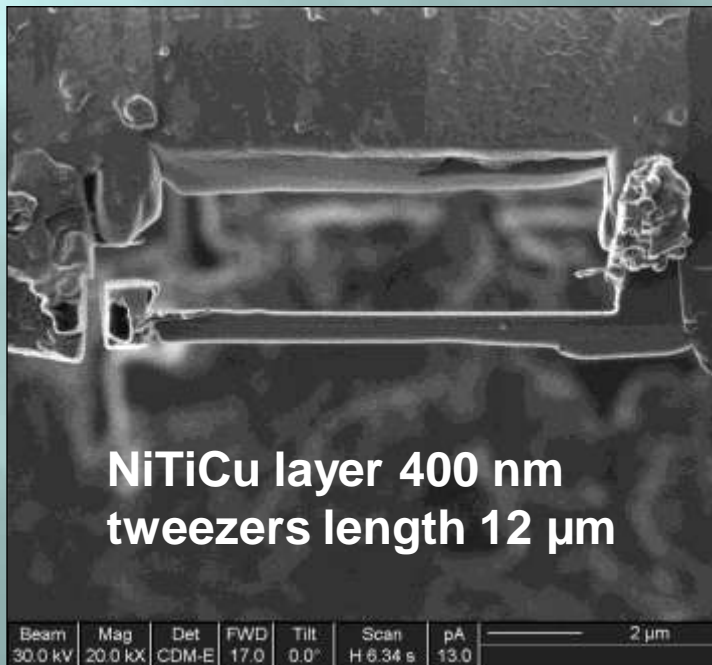
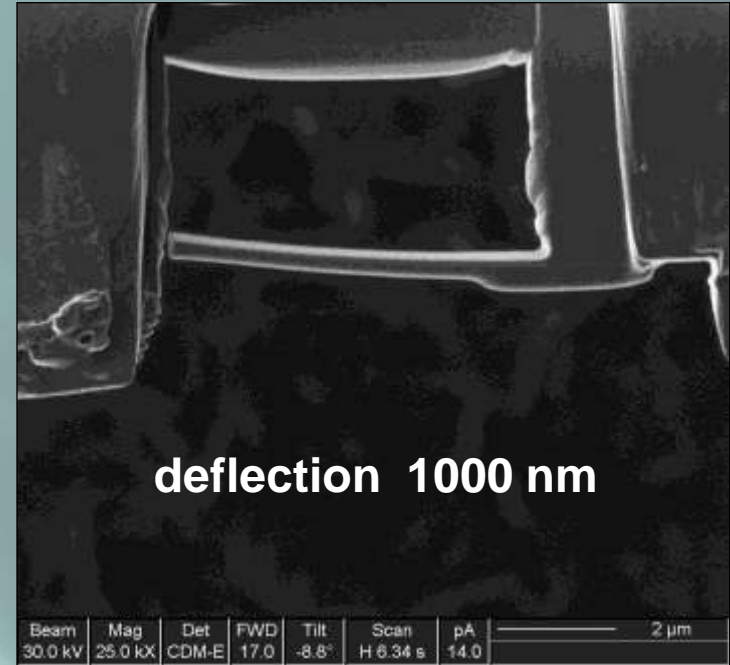
**30 μm NiTiCu / 30 μm Ni
(galvanic deposition)**

reversible bending deformation about 1 %

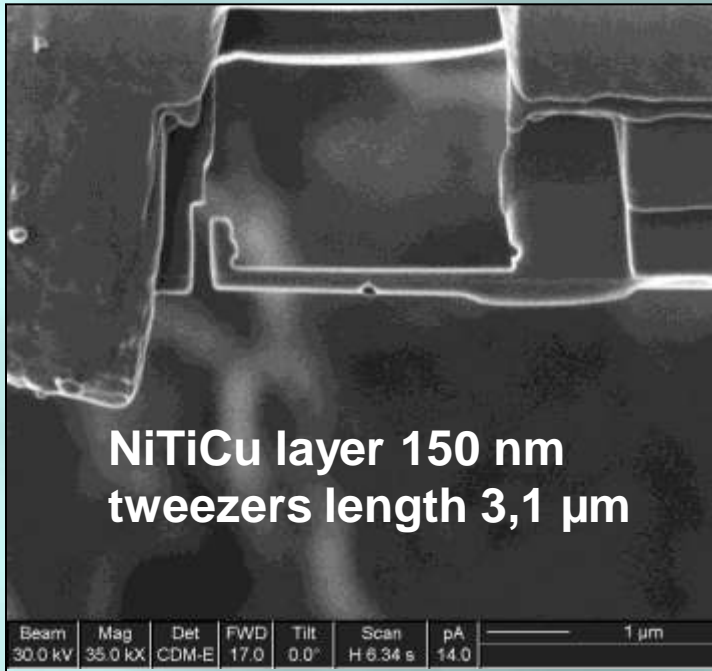
without heating



while heating



without heating



while heating

