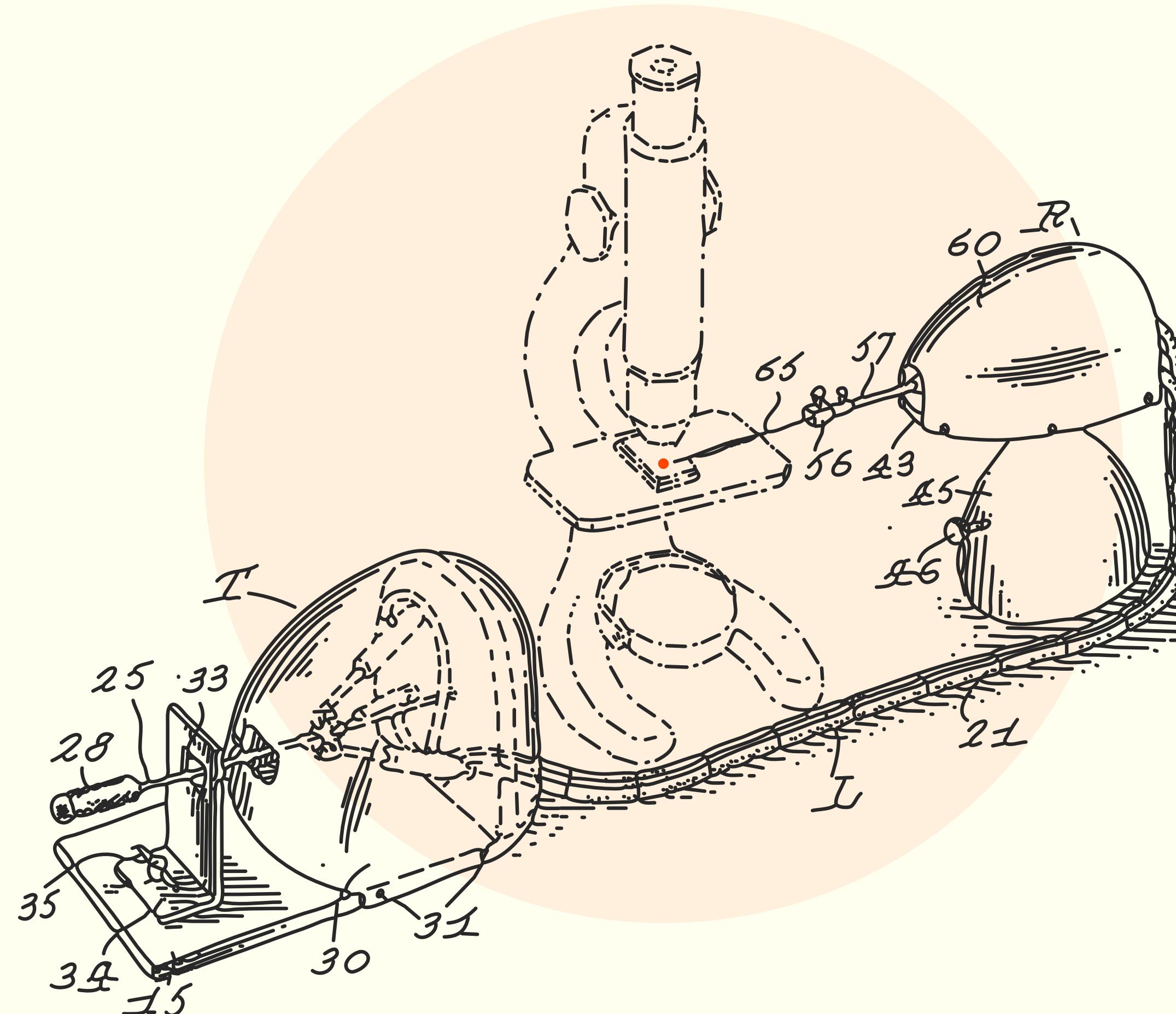


Micromanipulation



A course about manipulating
small things that should not be
manipulated.

February 22nd to
March 2nd
2018

Benjamin Maus
HfK Bremen

Micromanipulation

bottom-up

Scales Of Things

natural self-assembly

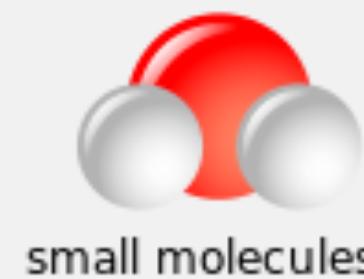
UV lithography

electron-beam lithography

nano-imprint lithography

scanning probe lithography

top-down



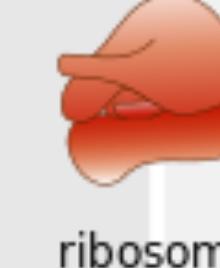
small molecules



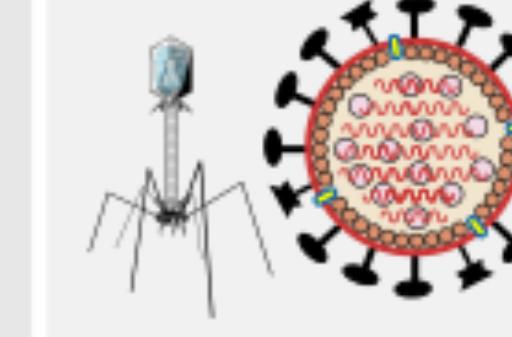
atoms



proteins,
antibodies



ribosomes



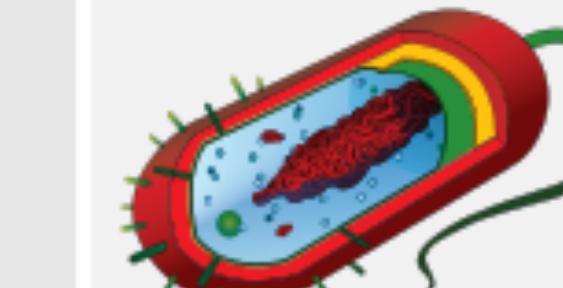
viruses



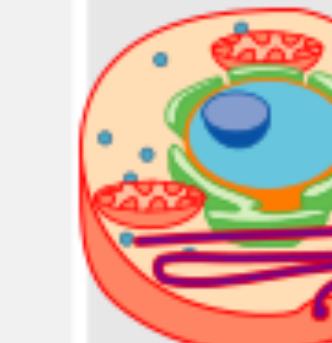
genes



animal cells



bacteria



chromosomes



human hair

0.1 nm

1 nm

10 nm

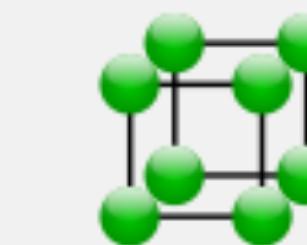
100 nm

1 µm

10 µm

100 µm

1 mm



crystalline lattices



carbon nanotubes



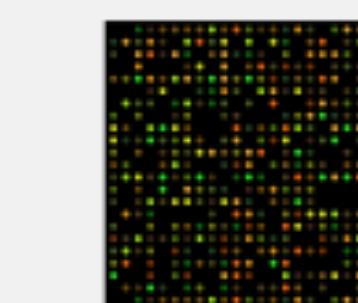
quantum dots



gates of transistors



electromechanical, fluidic, optical,
magnetic microsystems

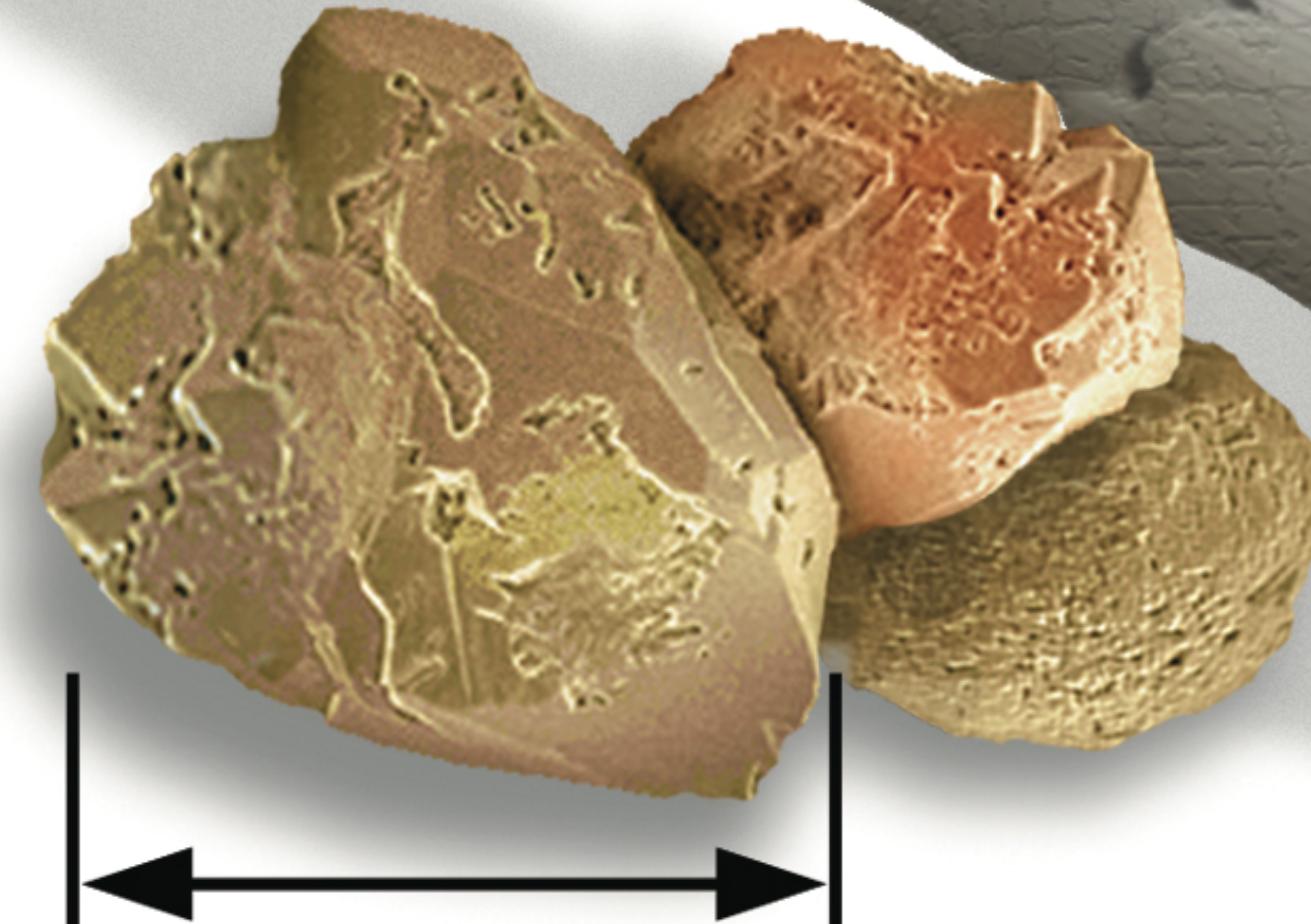


DNA microarrays

Micromanipulation

Scales

HUMAN HAIR
50-70 μm
(microns) in diameter



90 μm (microns) in diameter
FINE BEACH SAND

● PM_{2.5}

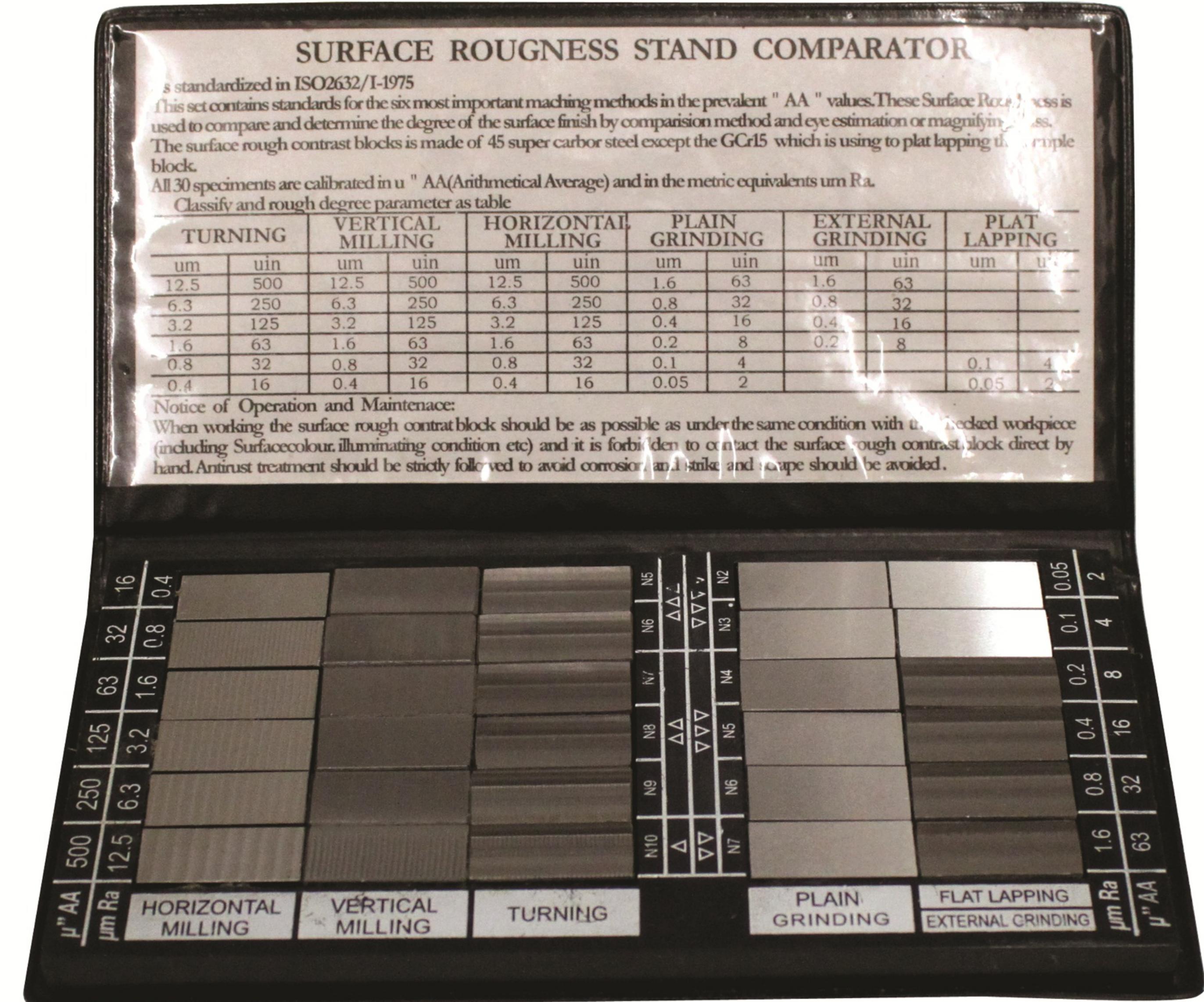
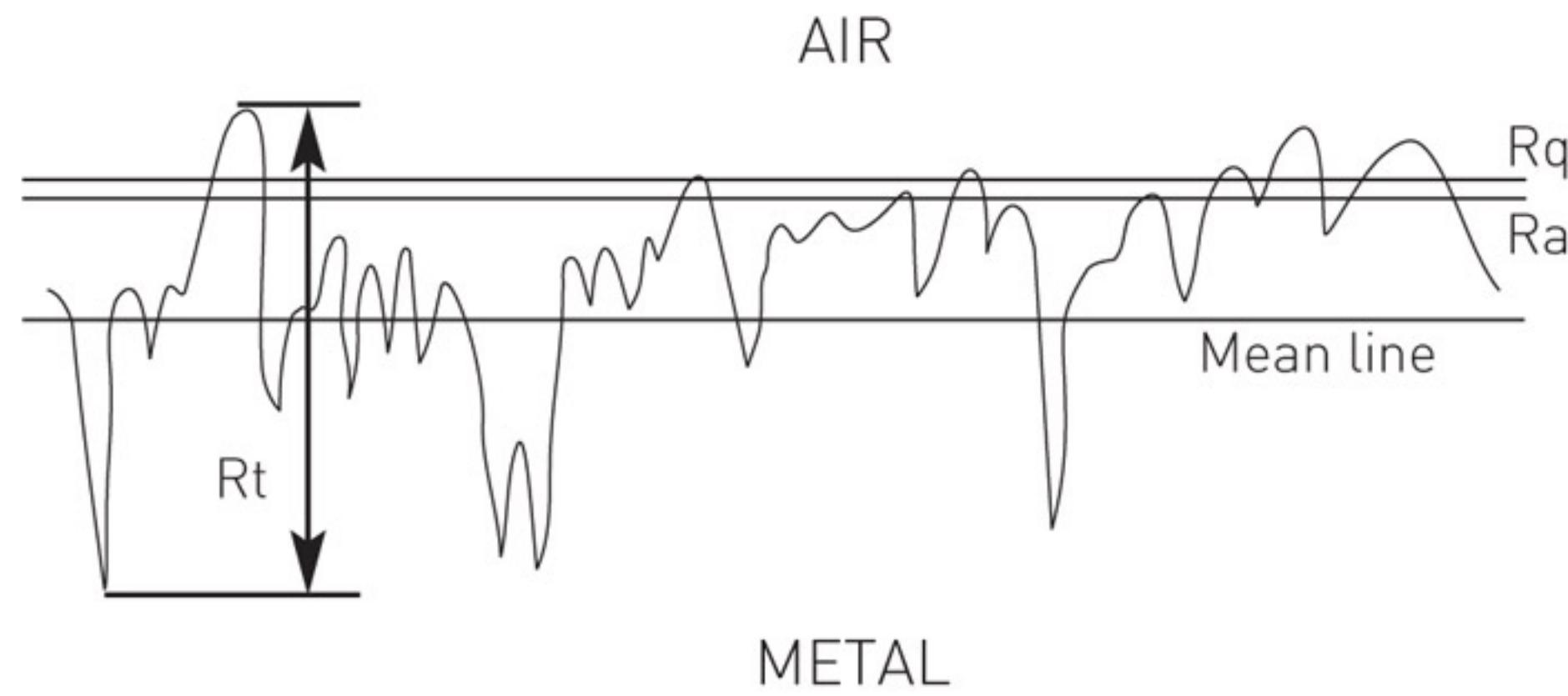
Combustion particles, organic compounds, metals, etc.
< 2.5 μm (microns) in diameter

● PM₁₀

Dust, pollen, mold, etc.
< 10 μm (microns) in diameter

Micromanipulation

Surface Roughness



Micromanipulation

Precision

Accuracy

Präzision

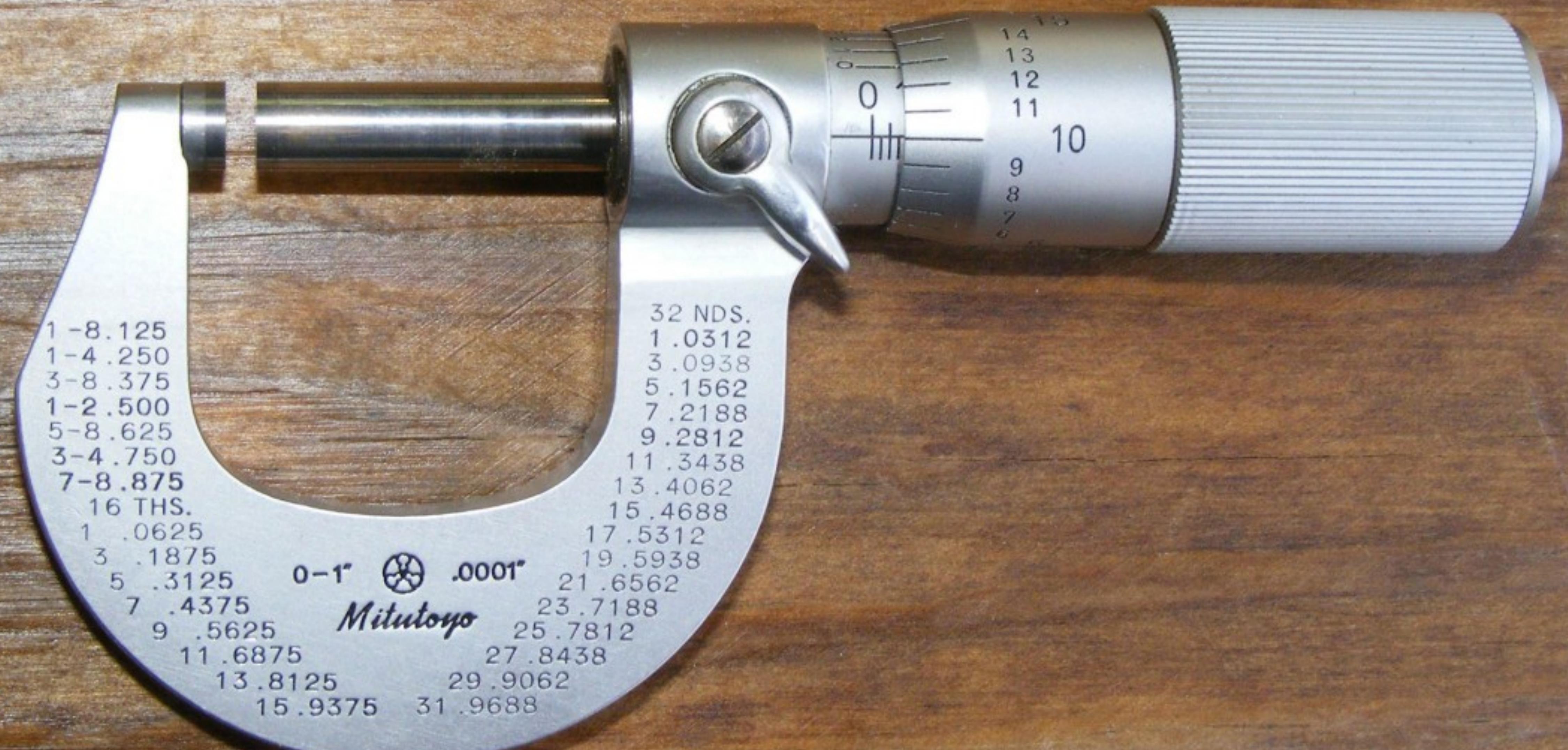
Genaugkeit

Micromanipulation

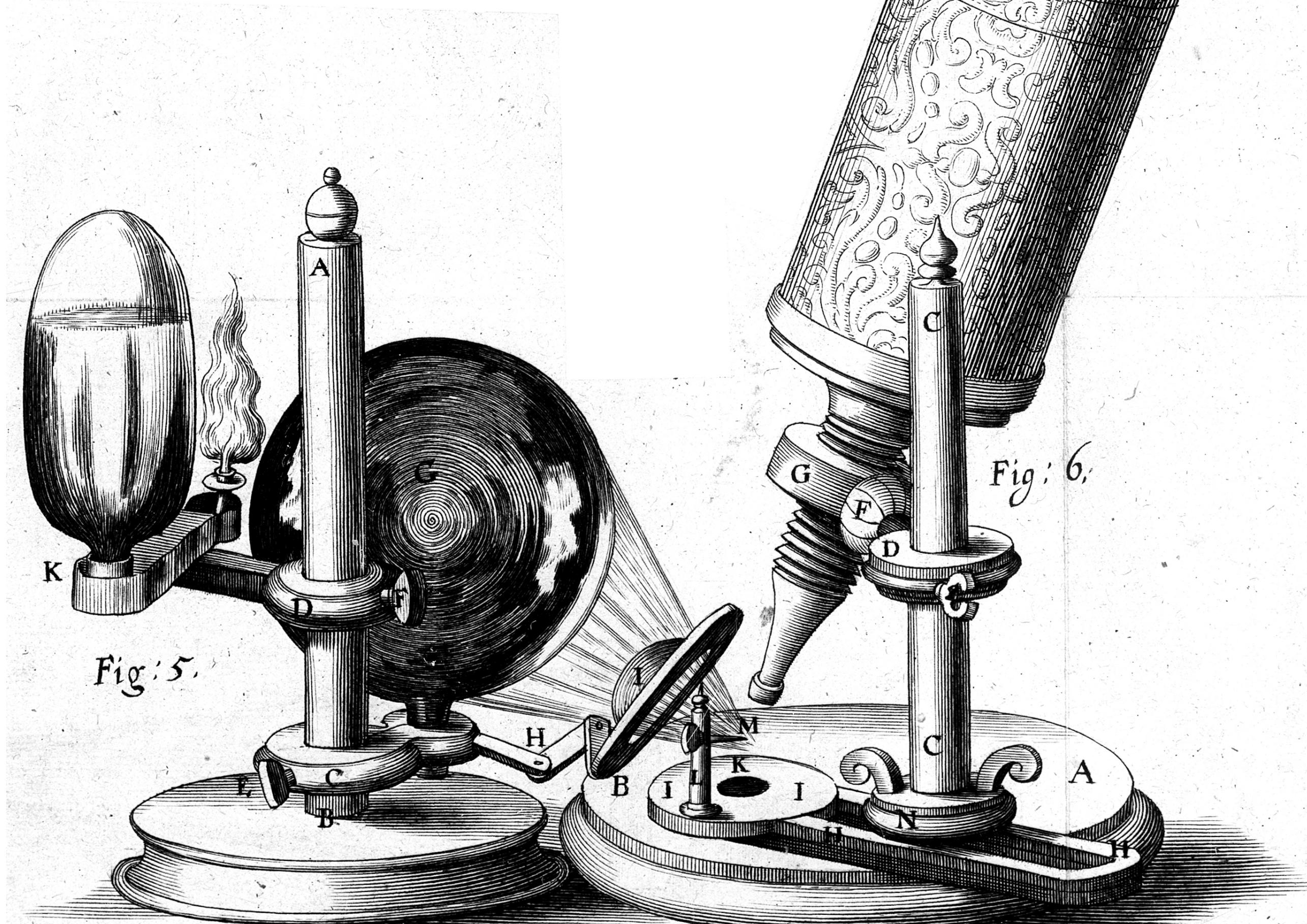


Micromanipulation

Micrometre



Micromanipulation

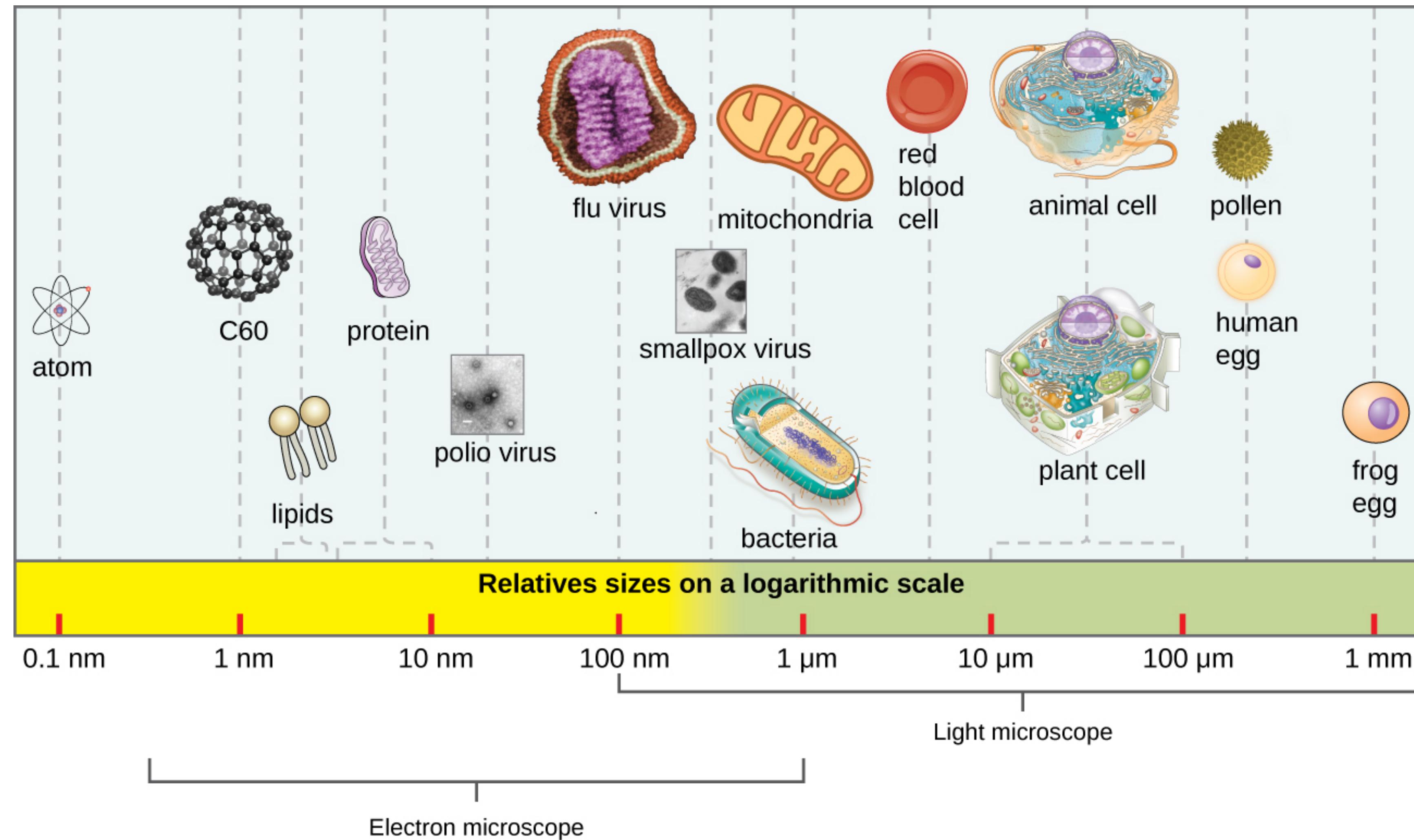


Microscopy



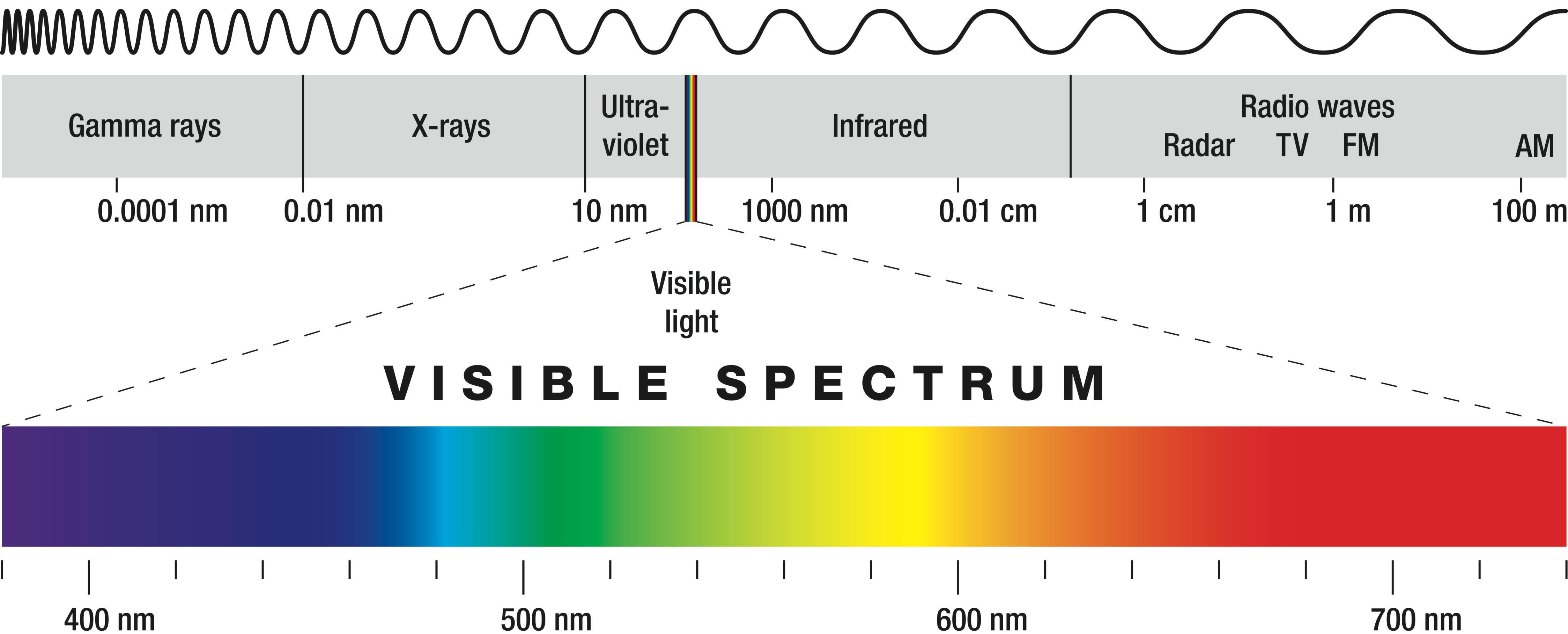
Micromanipulation

Scales Of Biology



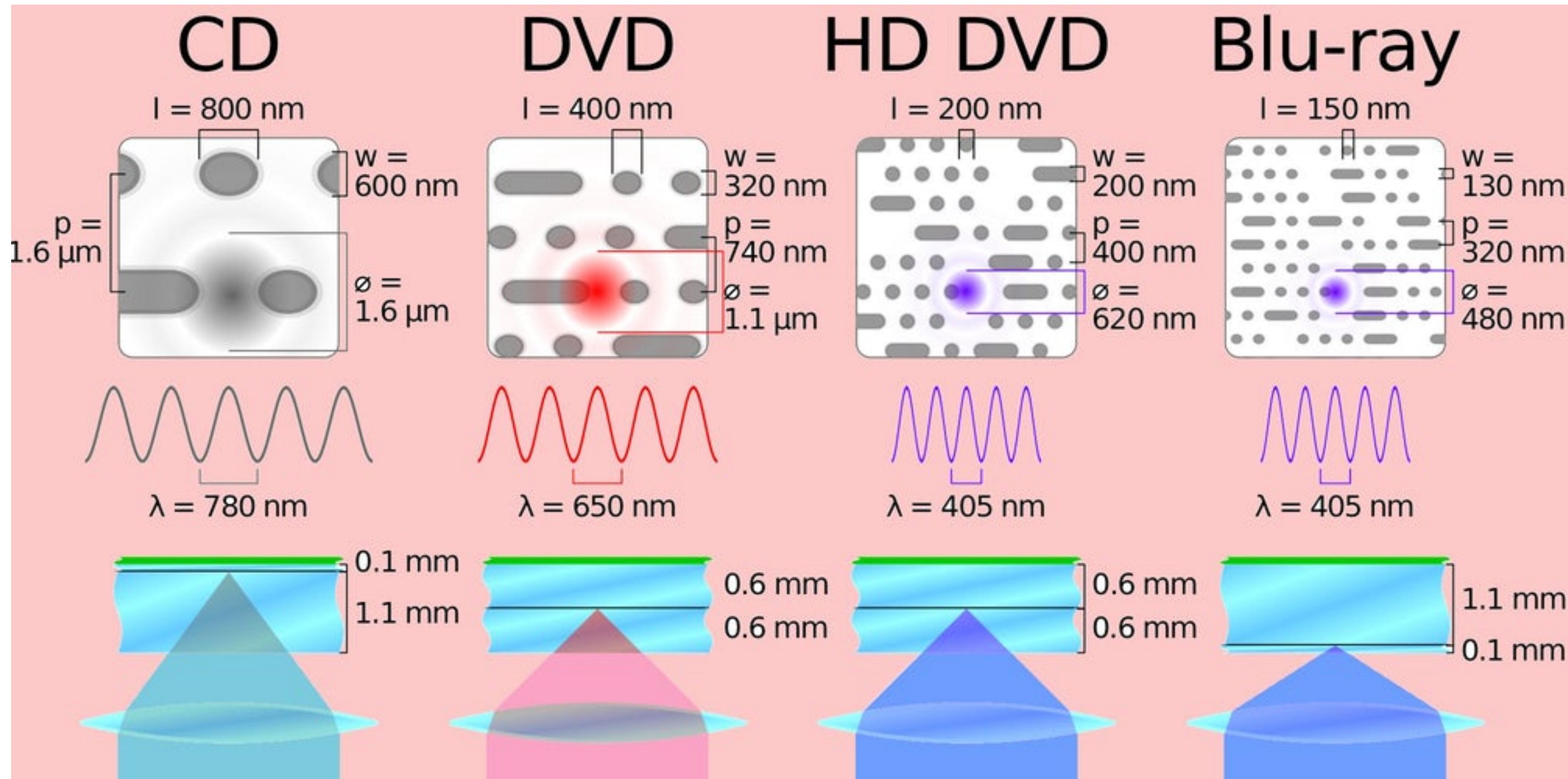
Micromanipulation

Electromagnetic Spectrum



Micromanipulation

Optical Data Storage



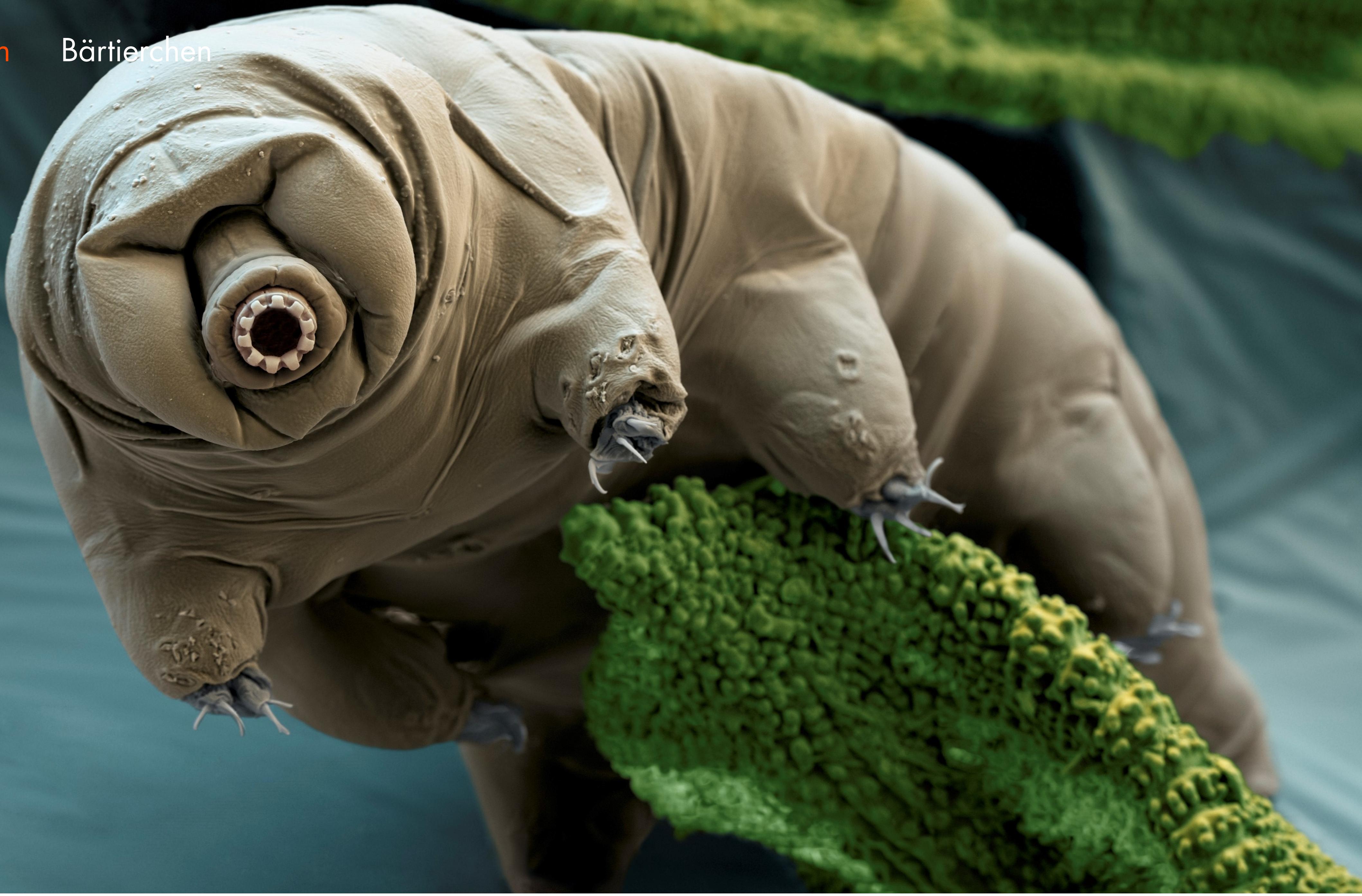
Micromanipulation

Scanning Electron Microscope



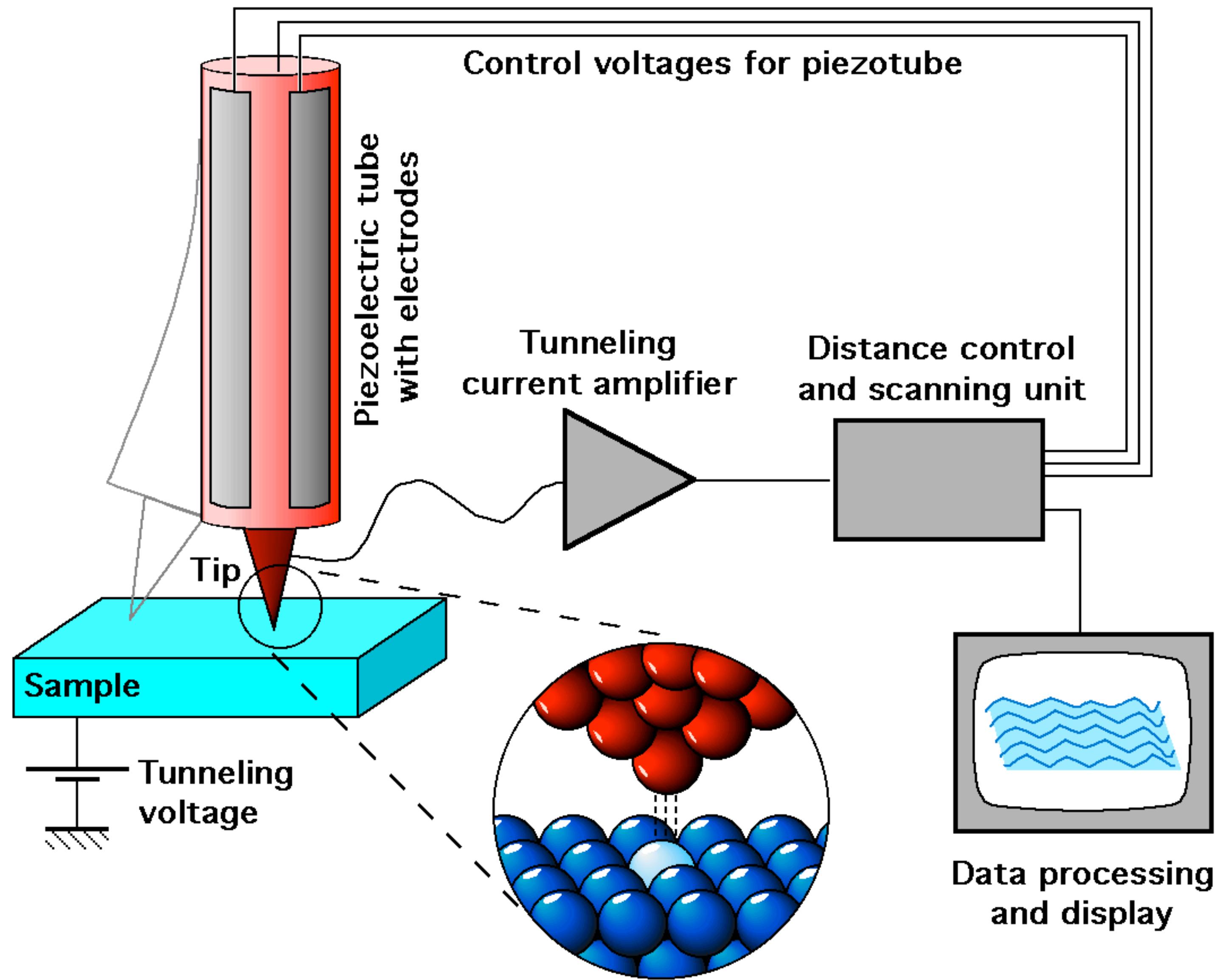
Micromanipulation

Bärtierchen



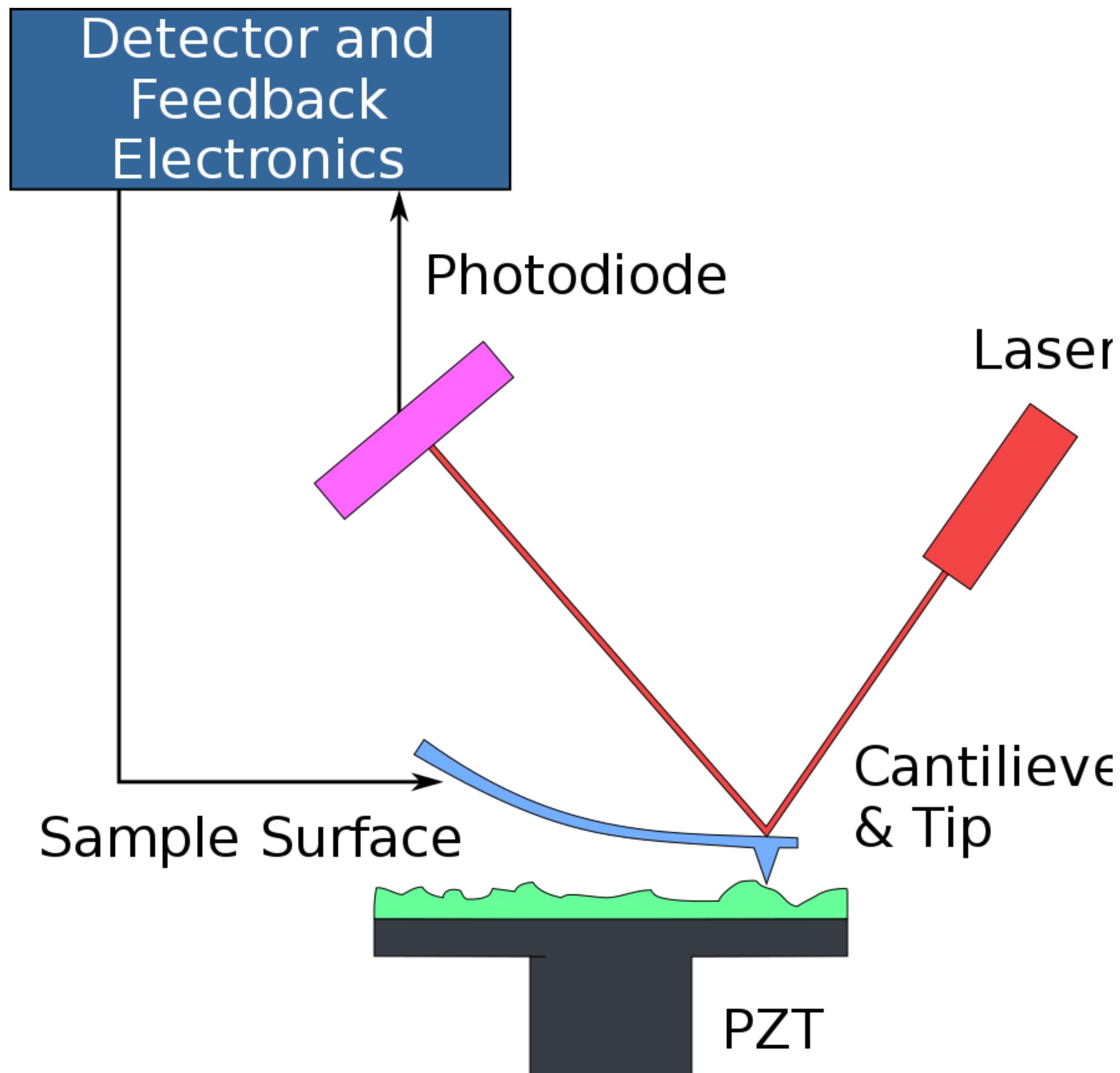
Micromanipulation

Scanning Tunneling Microscope



Micromanipulation

AFM

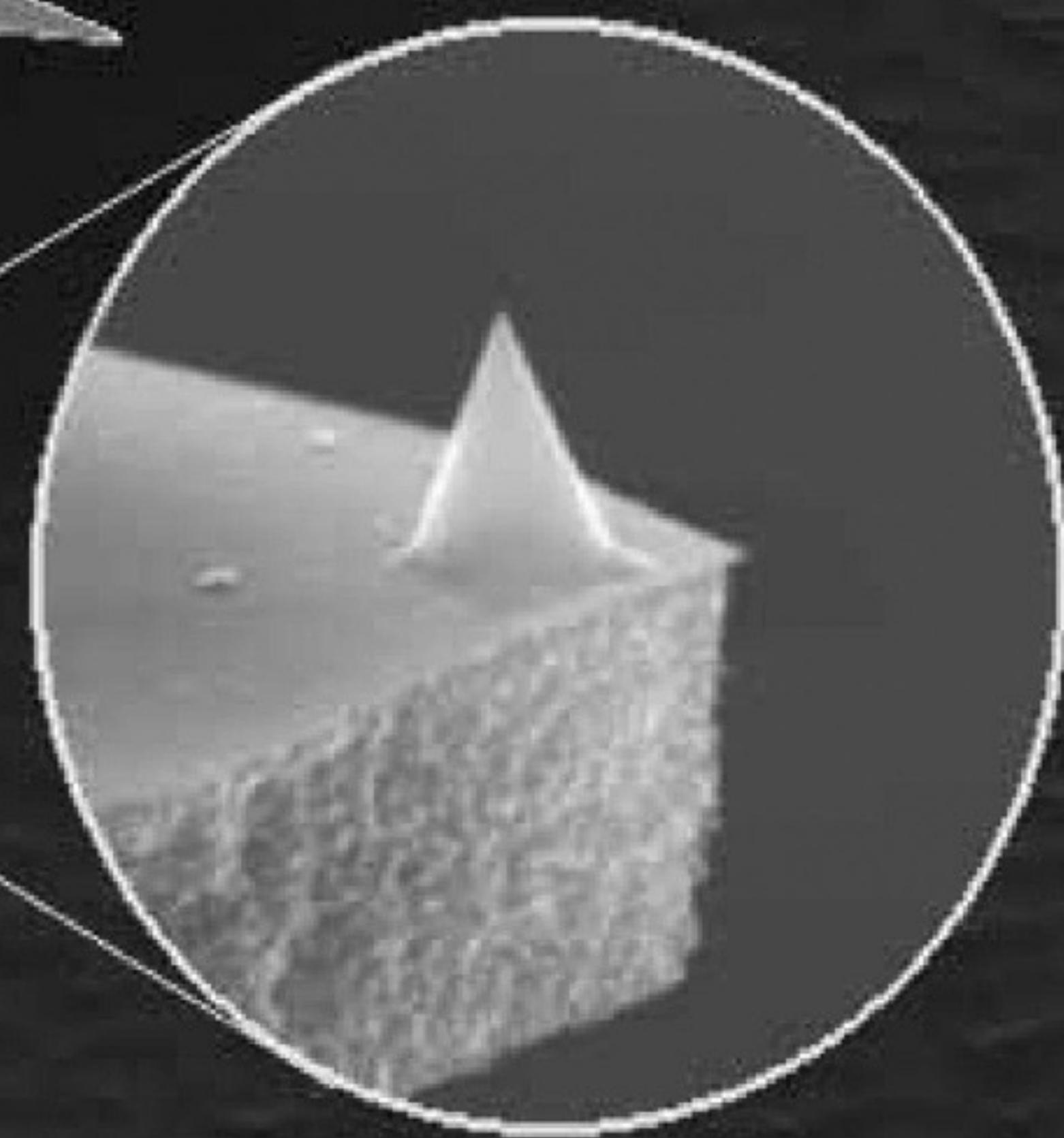


Micromanipulation

AFM Tip

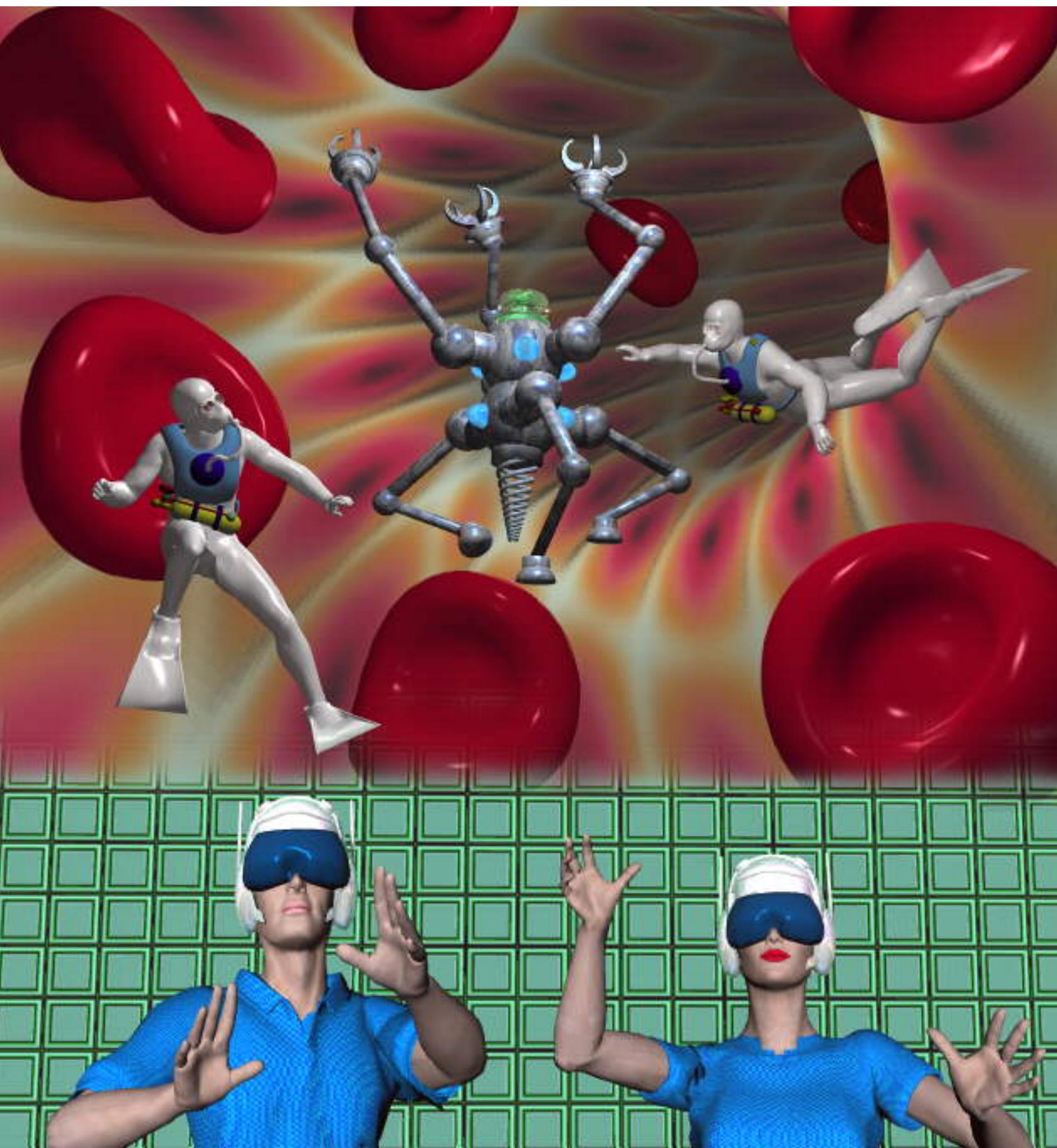
Magn
30x

500 µm
IMT-Neuchatel



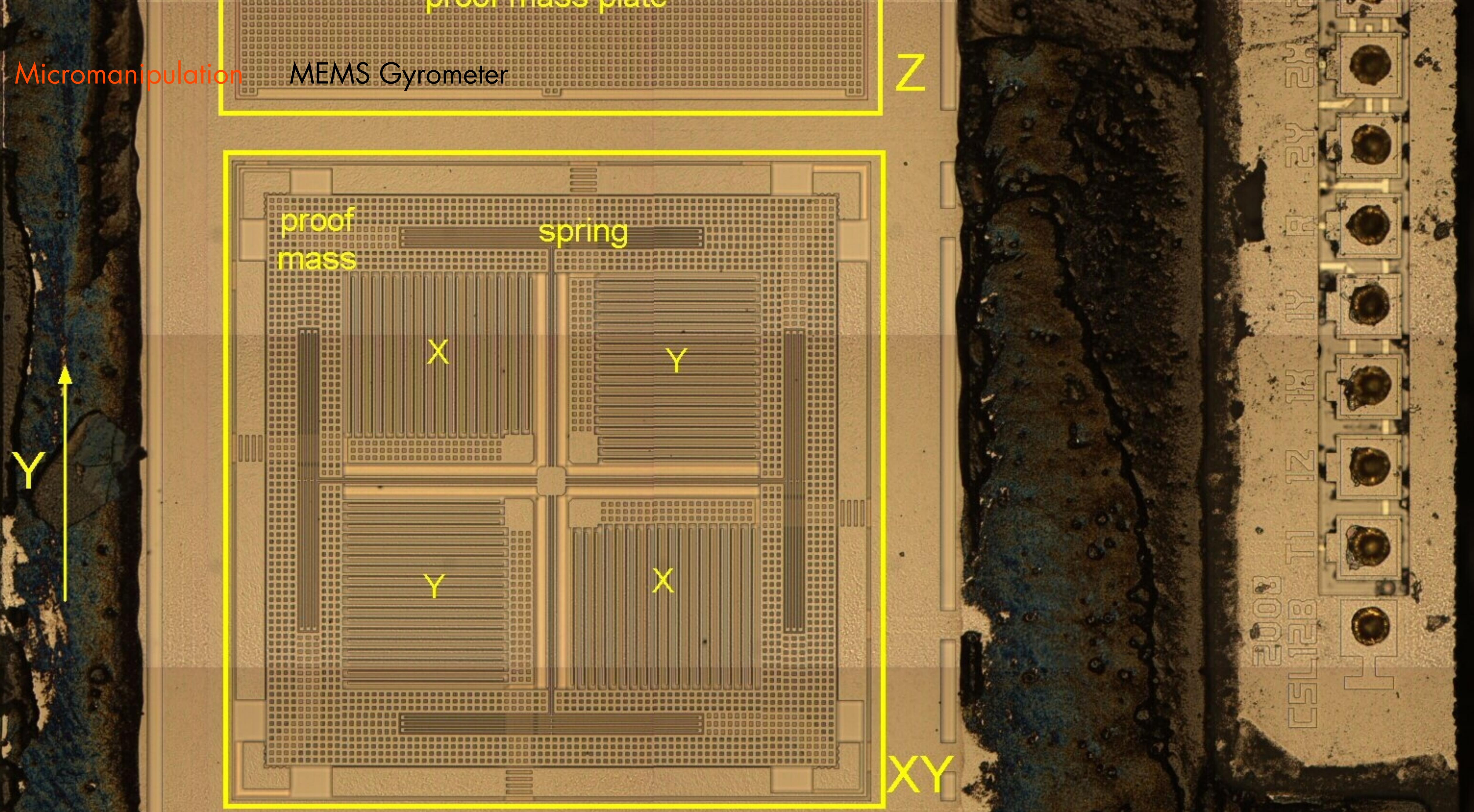
Micromanipulation

Micromachines

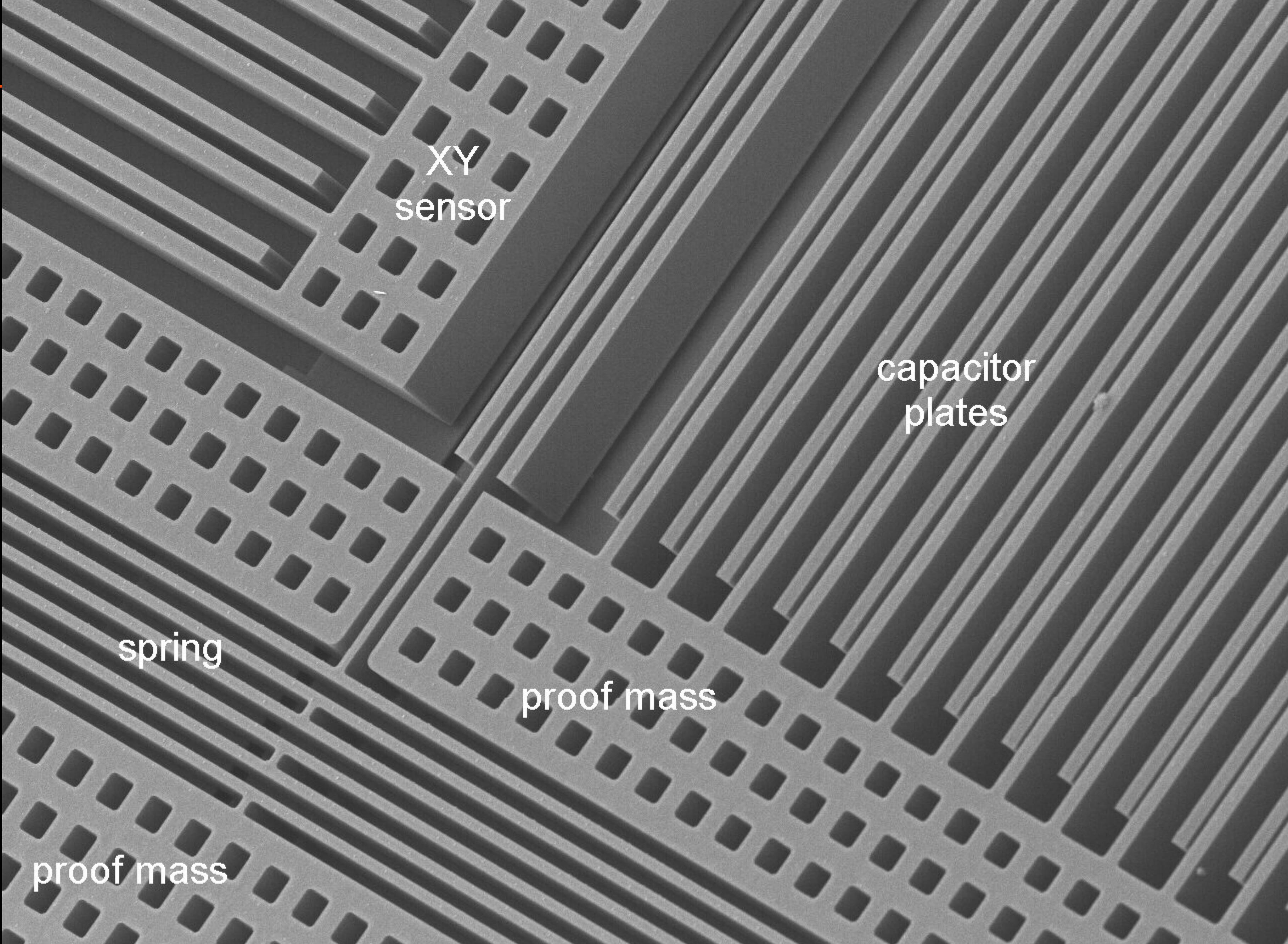


Micromanipulation

MEMS Gyrometer



Micromanipulator



Acc.V Spot Magn Det WD

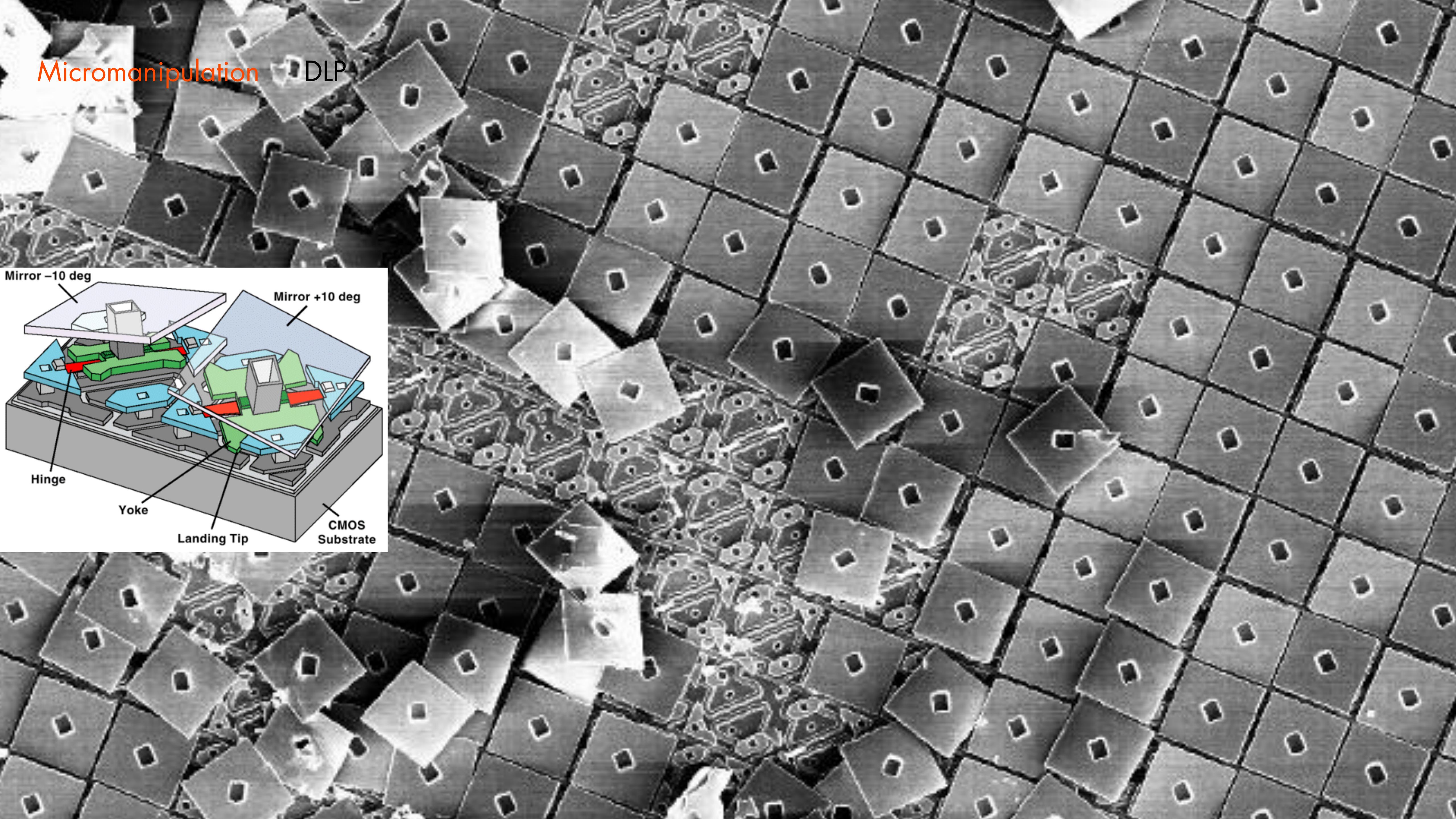
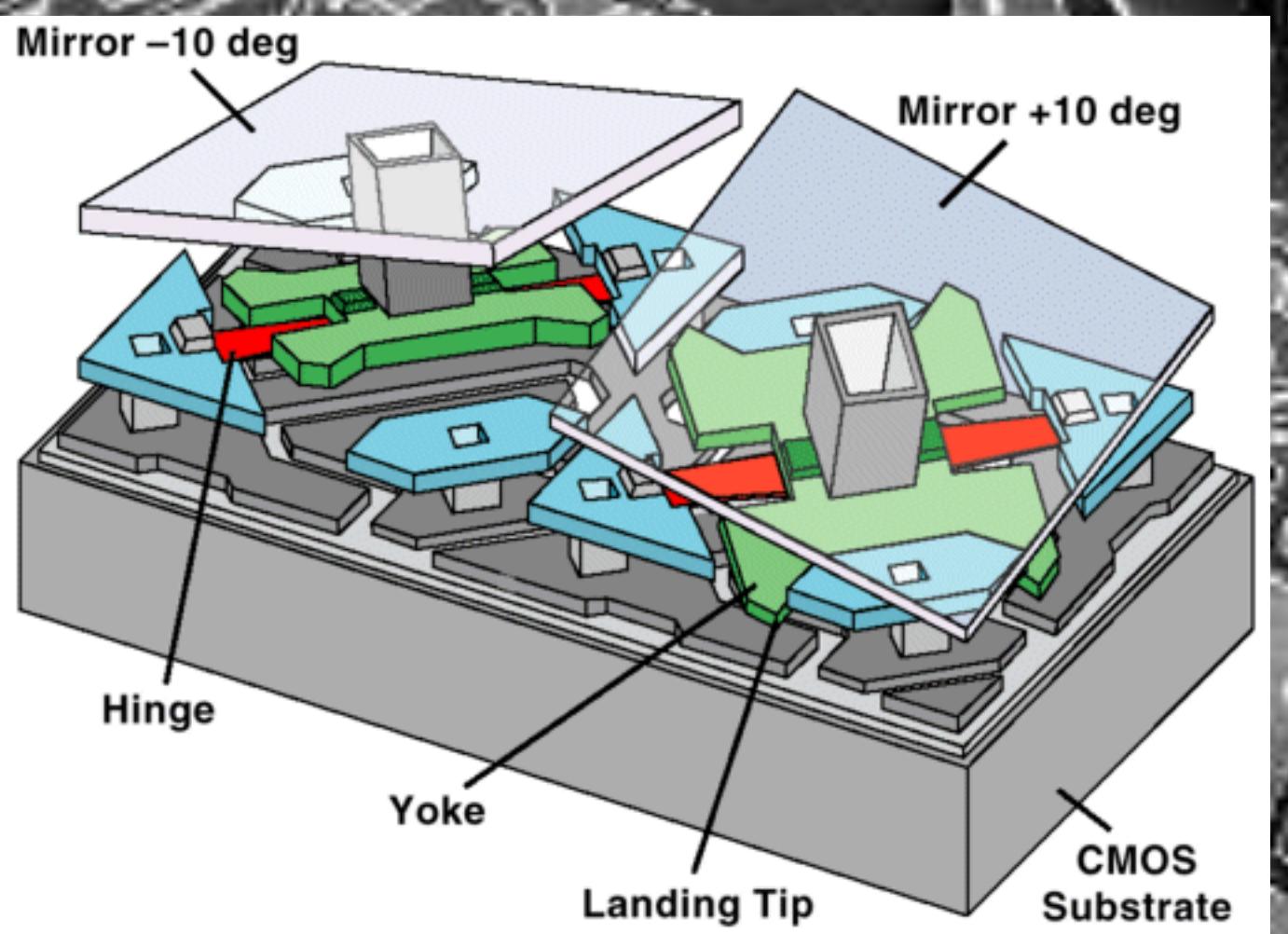
10.10 kV 3.0 650x SE 12.8

20 µm
ST Micro LIS331DLH CW TB

chipworks

Micromanipulation

DLP

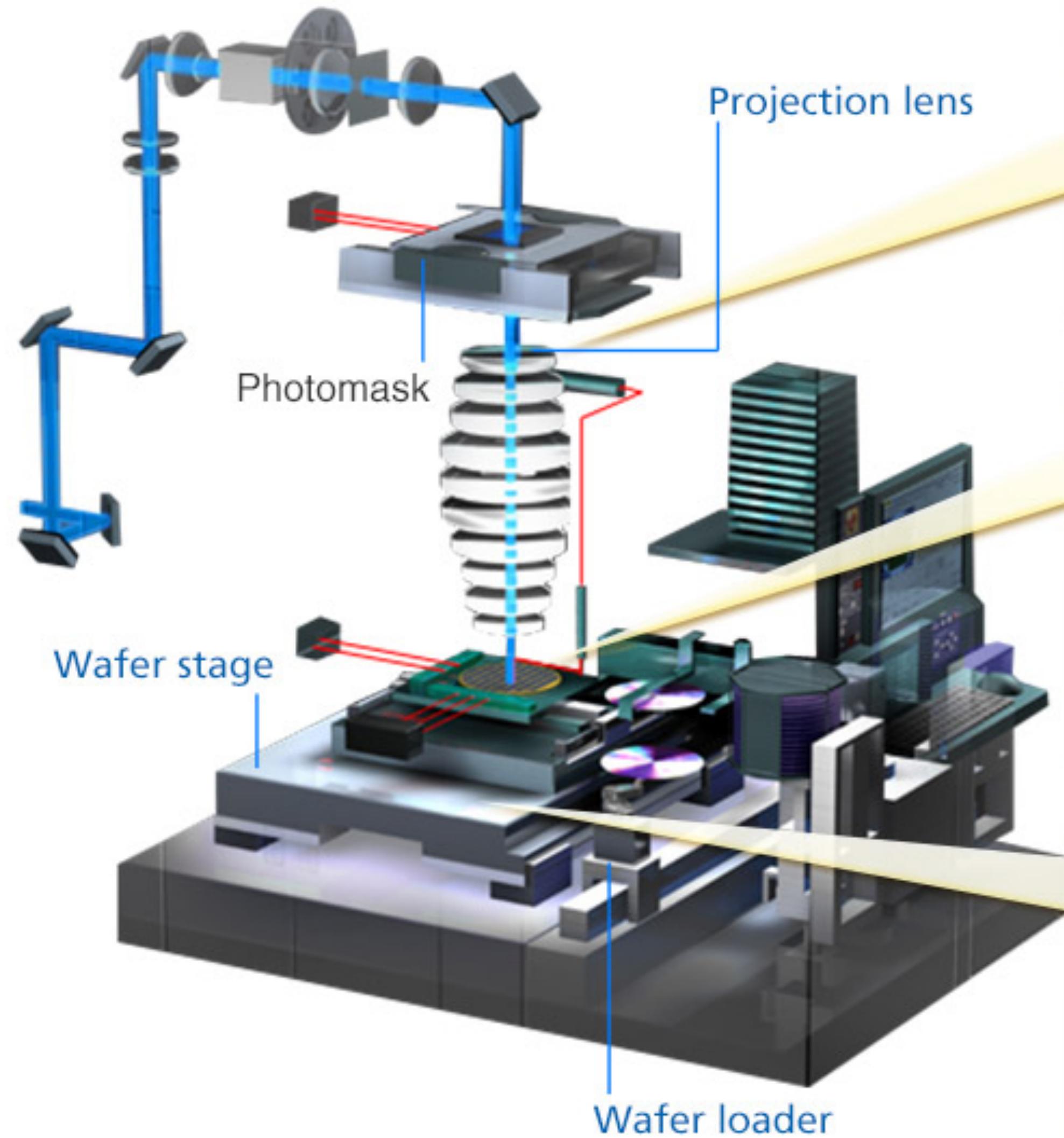


Micromanipulation

Semiconductor Fab



Three technologies that determine the performance of semiconductor lithography systems



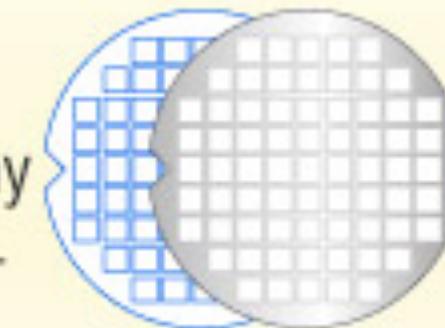
- 1 Resolution capability of the projection lens:** For forming extremely intricate electronic circuit patterns

The projection lens consists of more than 20 lenses. Some projection lenses are more than 1 meter long.



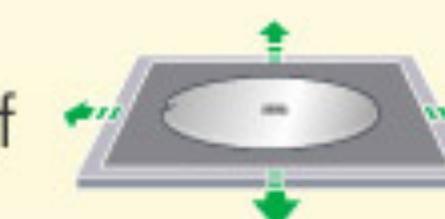
- 2 Alignment accuracy:** Ensuring that the next pattern is accurately aligned to the base pattern

When electronic circuit patterns are repeatedly formed on a silicon wafer many times, they must be positioned with accuracy to the nanometer level.



- 3 Throughput:** Indicates the processing efficiency of a semiconductor lithography system

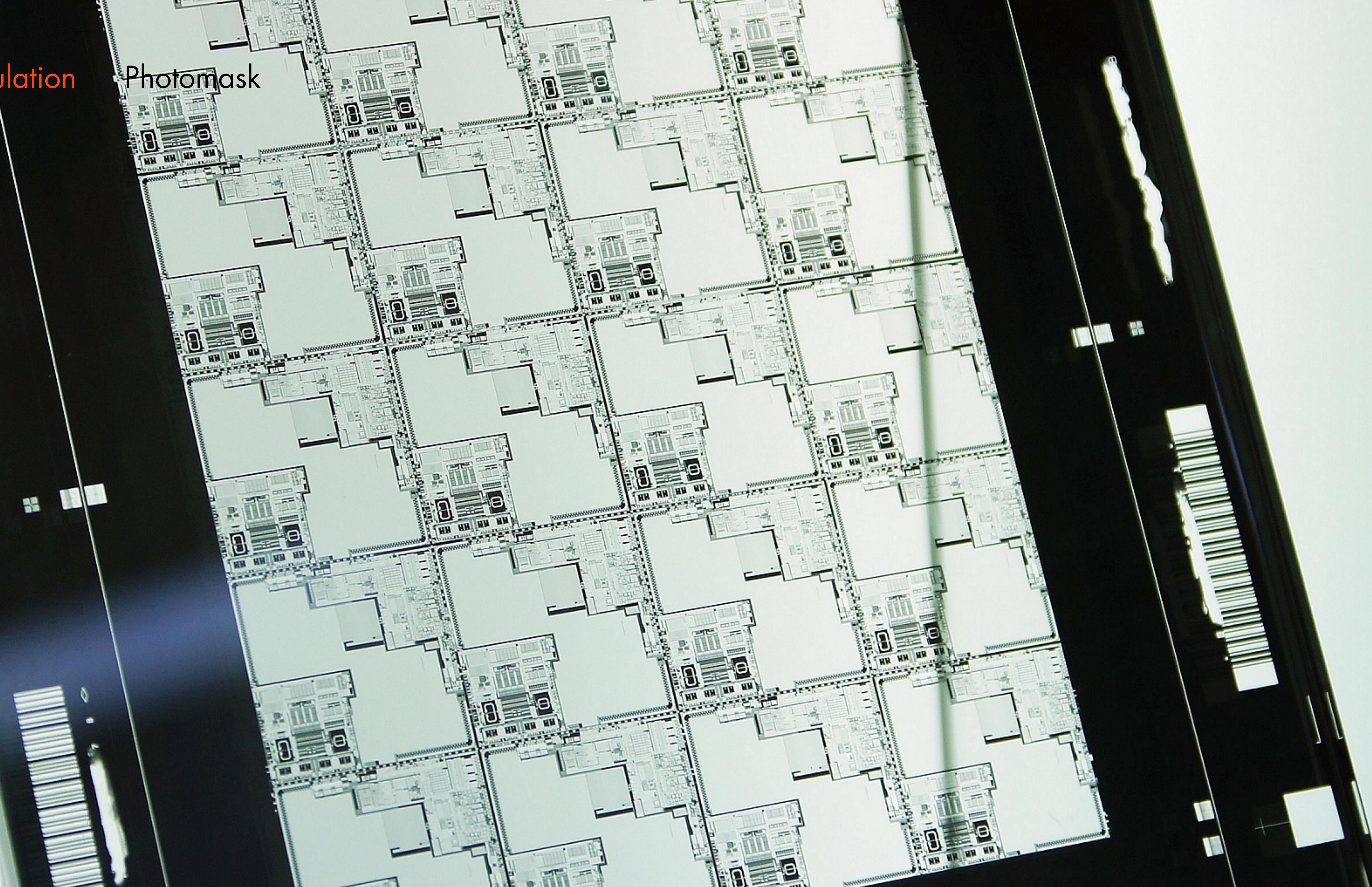
Productivity during IC mass production is improved when high-speed movements of the wafer stage and other processes increase throughput.



Micromanipulation

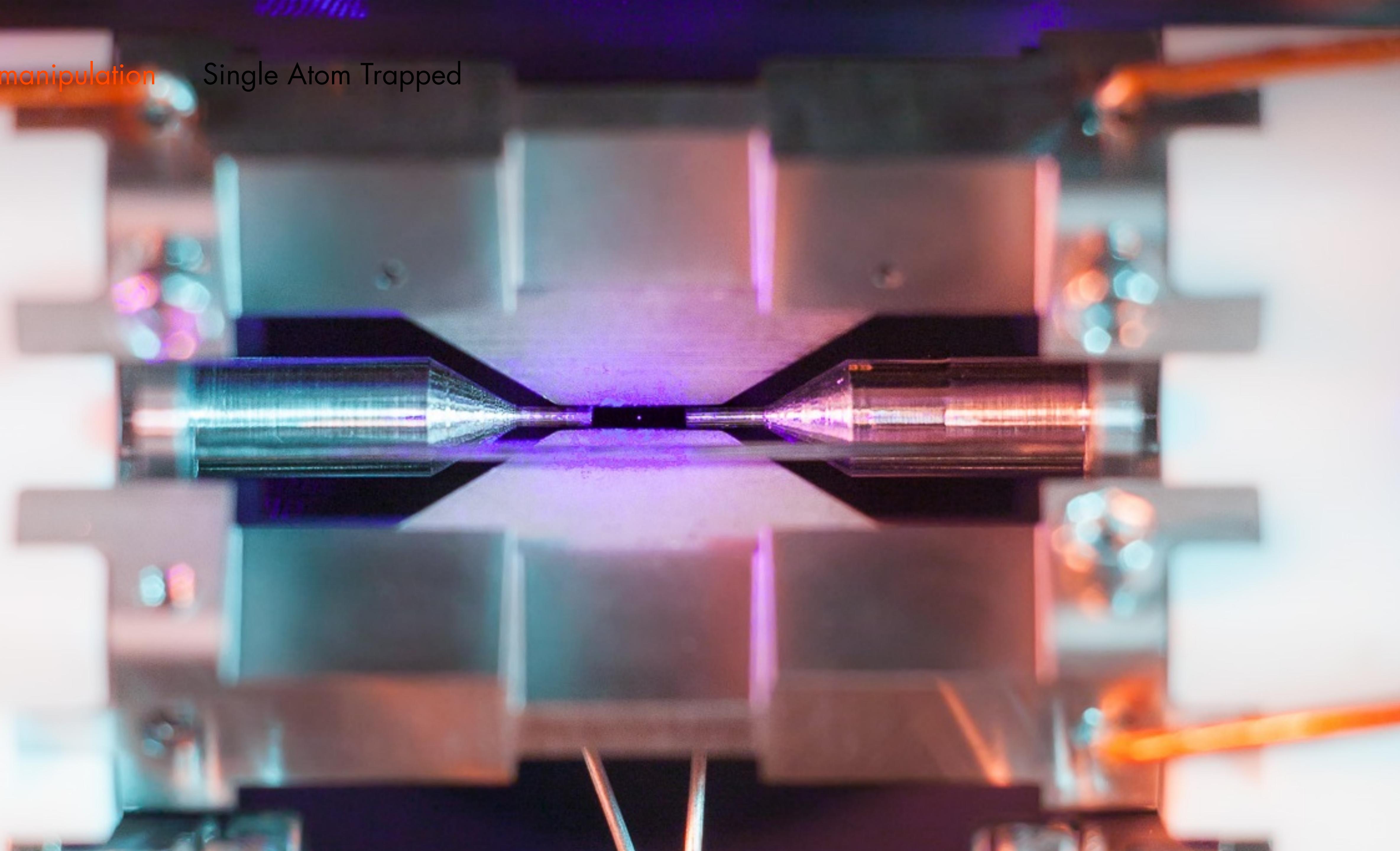
Photomask

IN TẤU
HÀM



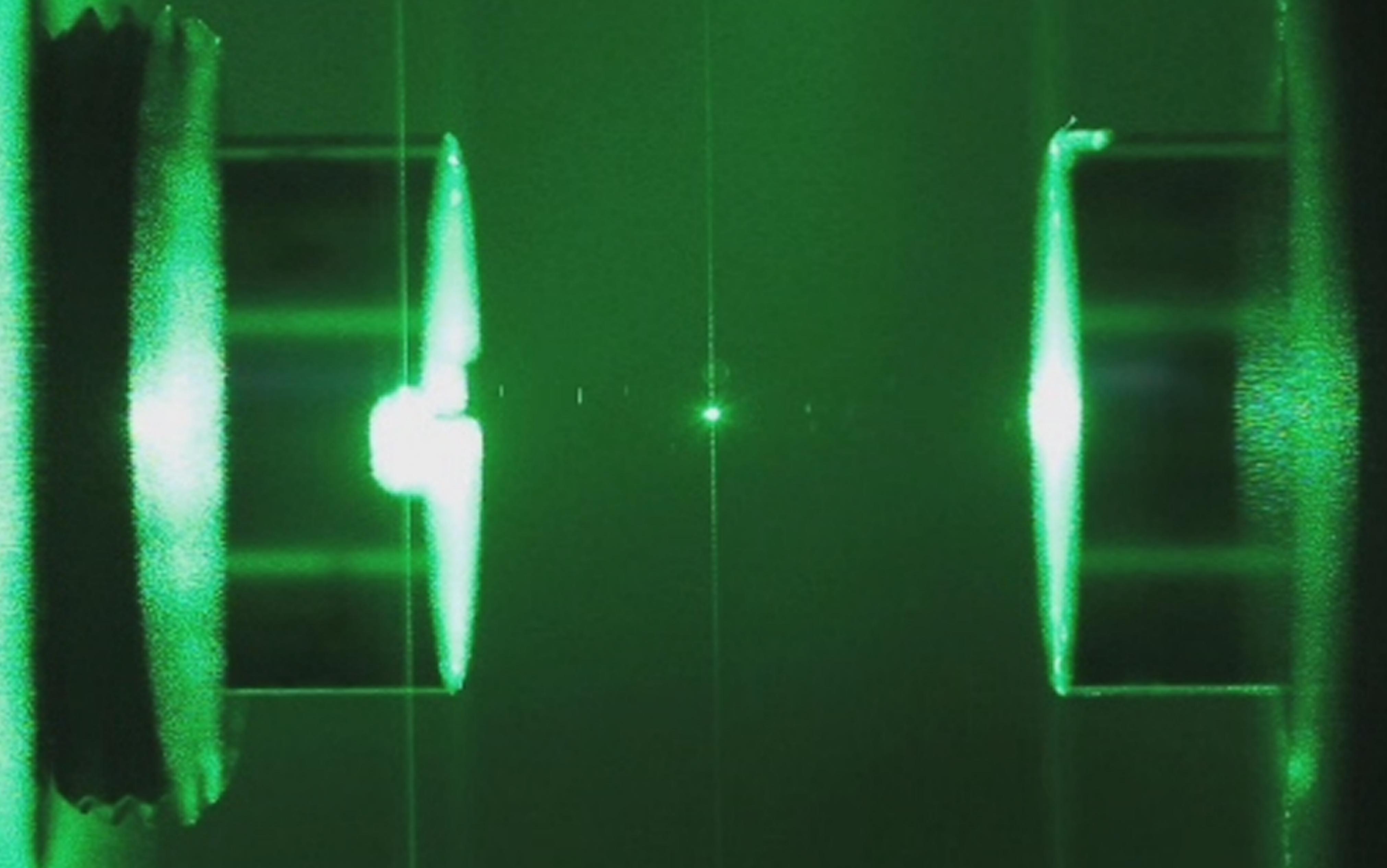
Micromanipulation

Single Atom Trapped



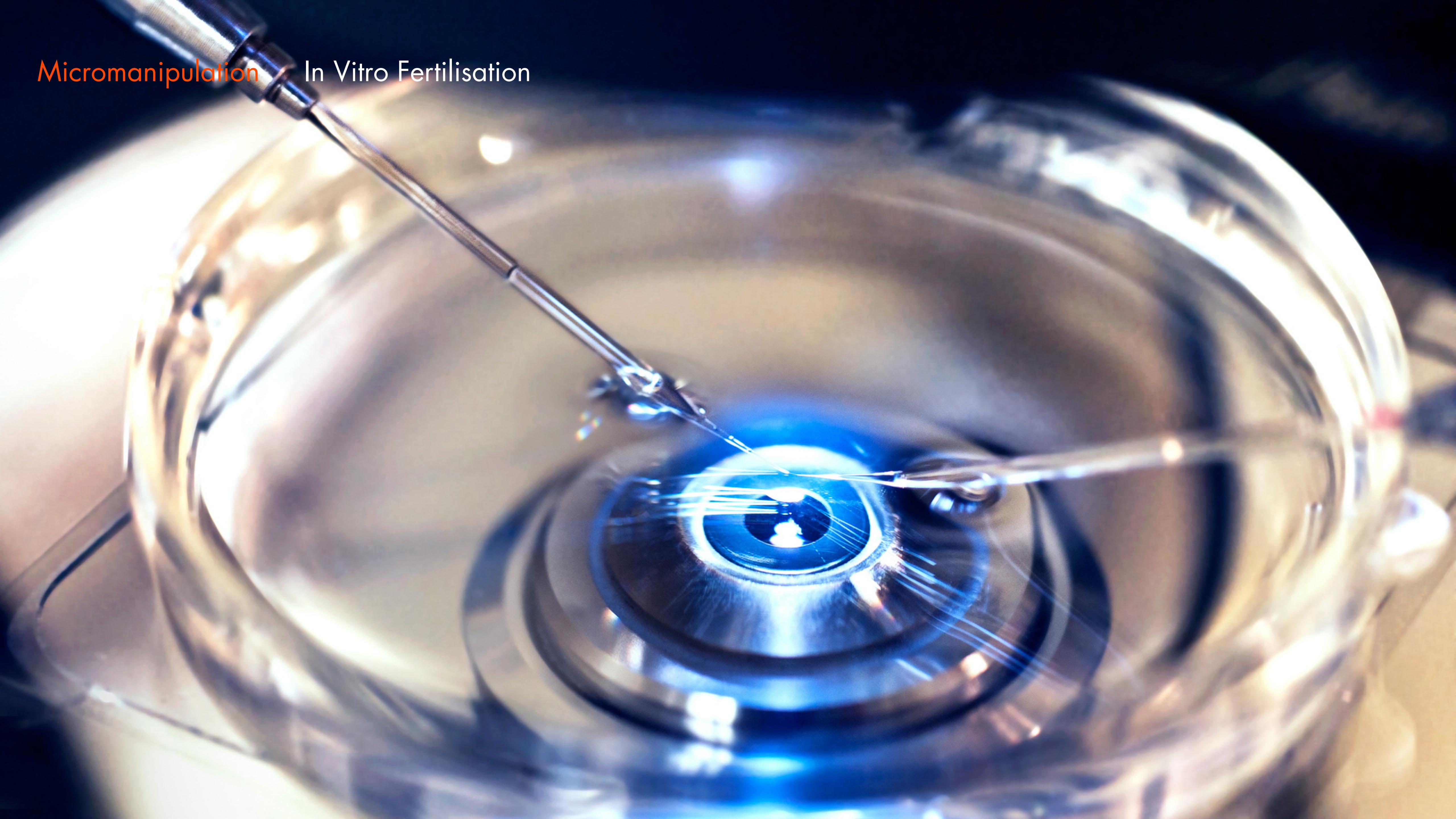
Micromanipulation

Optical Trap / Optical Tweezers



Micromanipulation

In Vitro Fertilisation



Micromanipulation

In Vitro Fertilisation



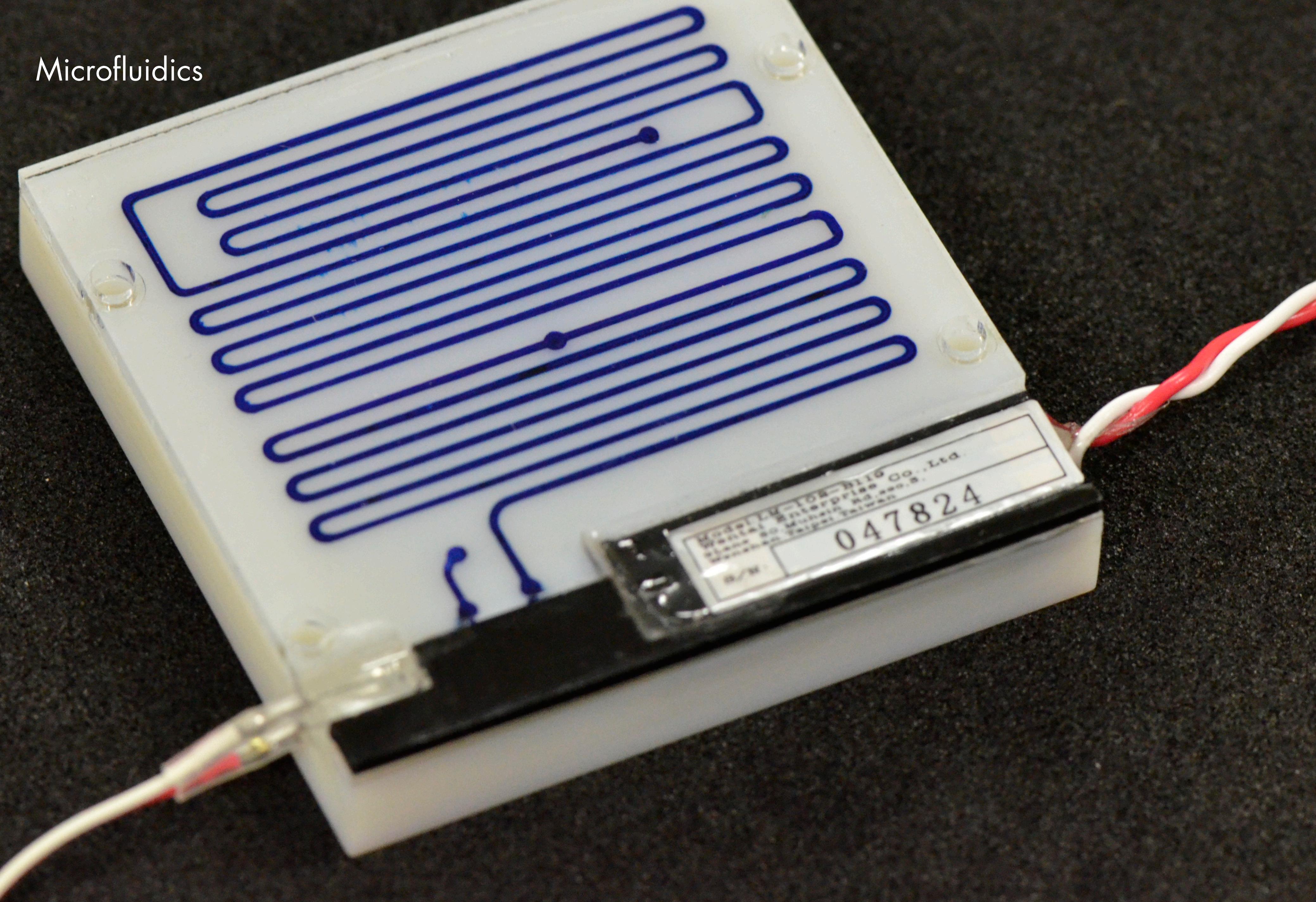
Micromanipulation

Micropipetting



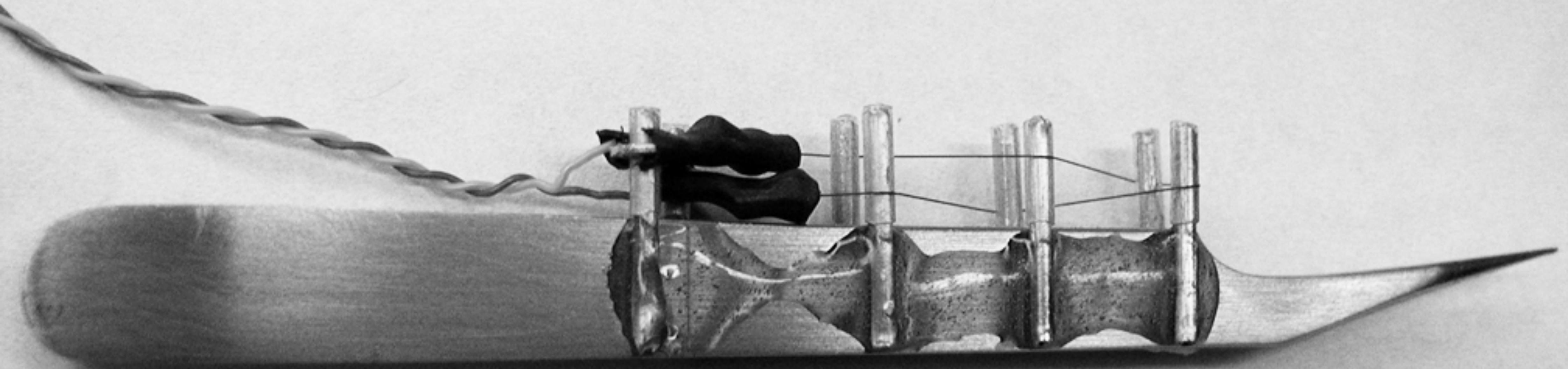
Micromanipulation

Microfluidics



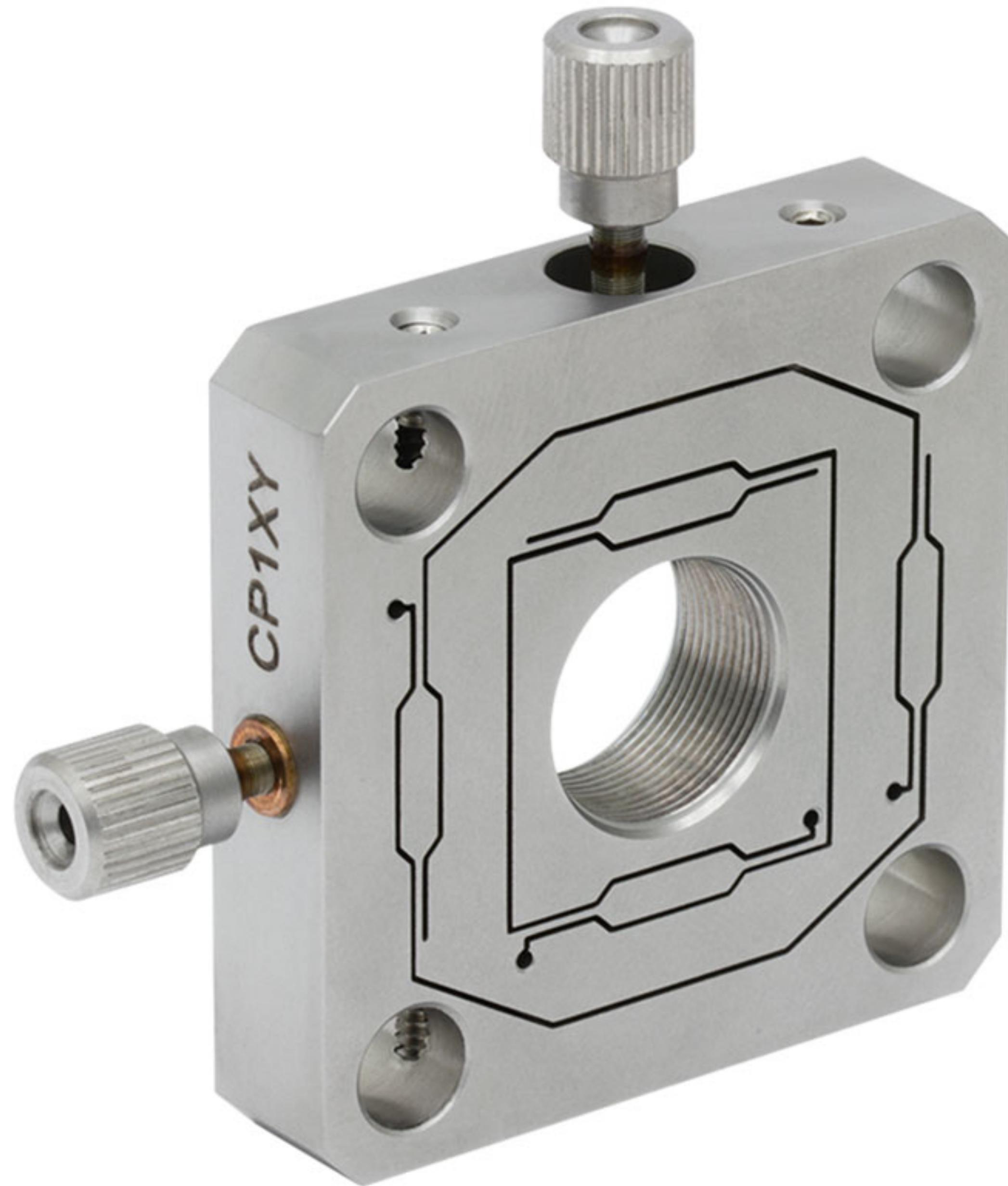
Micromanipulation

Muscle Wire Actuator



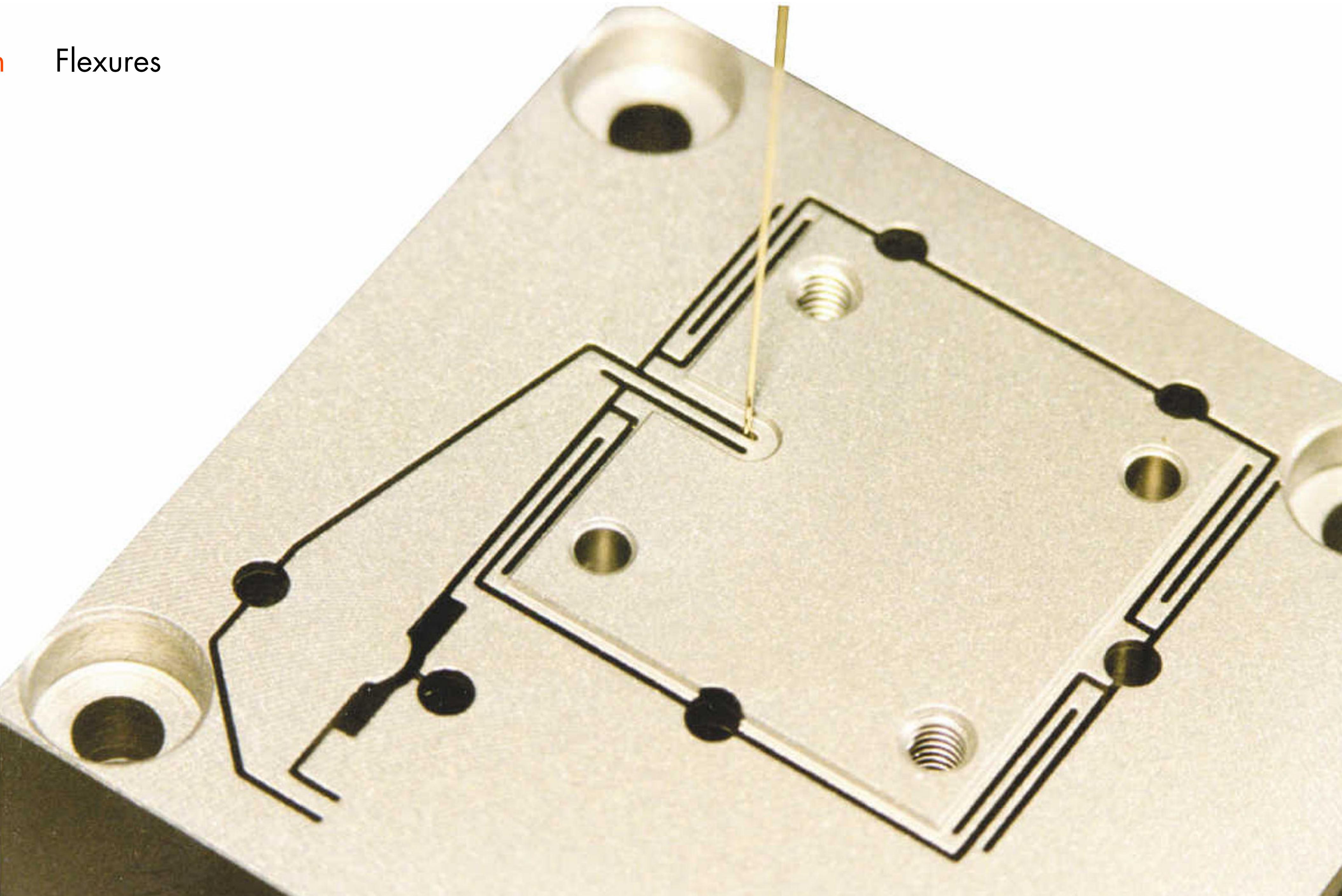
Micromanipulation

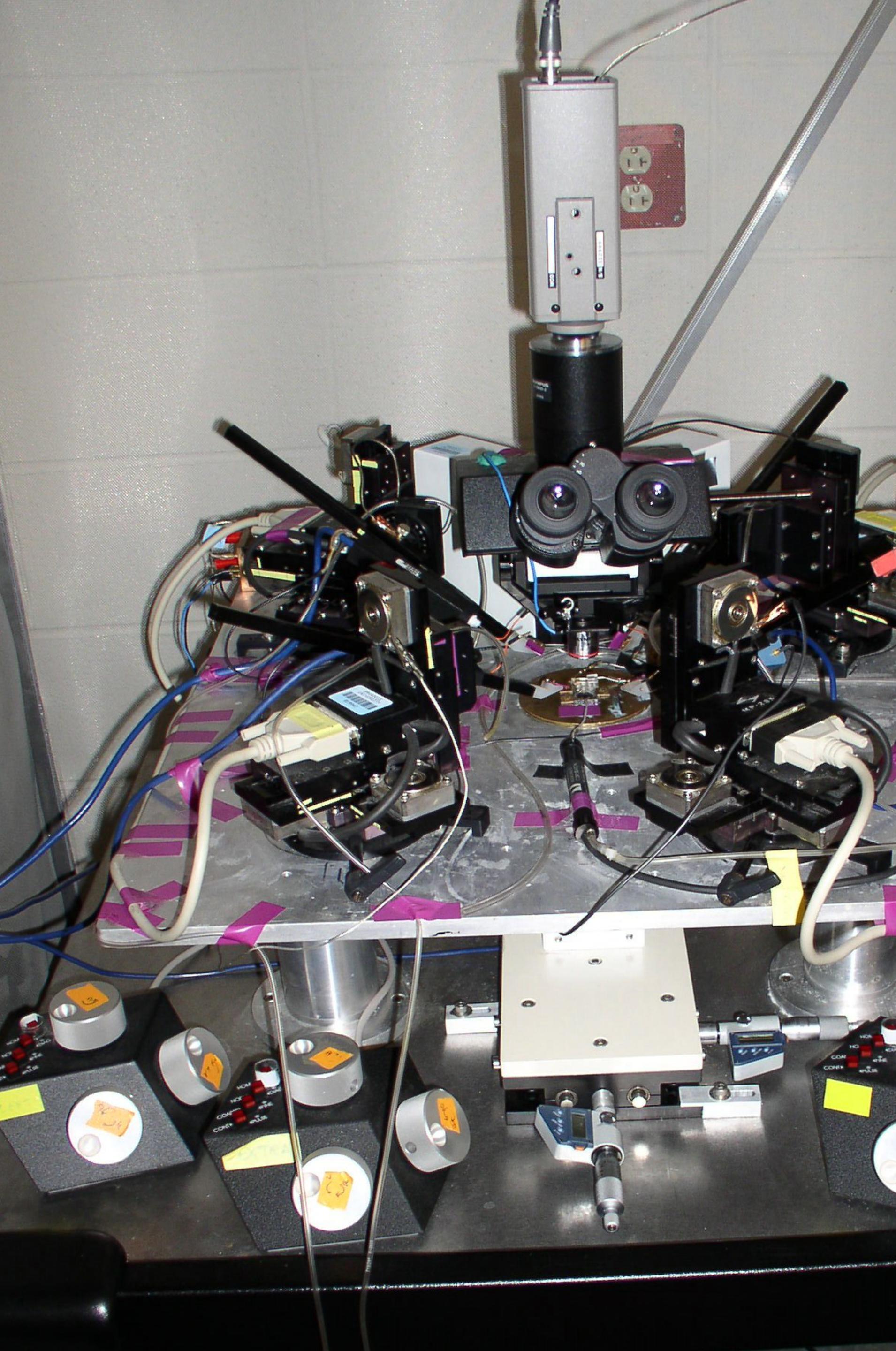
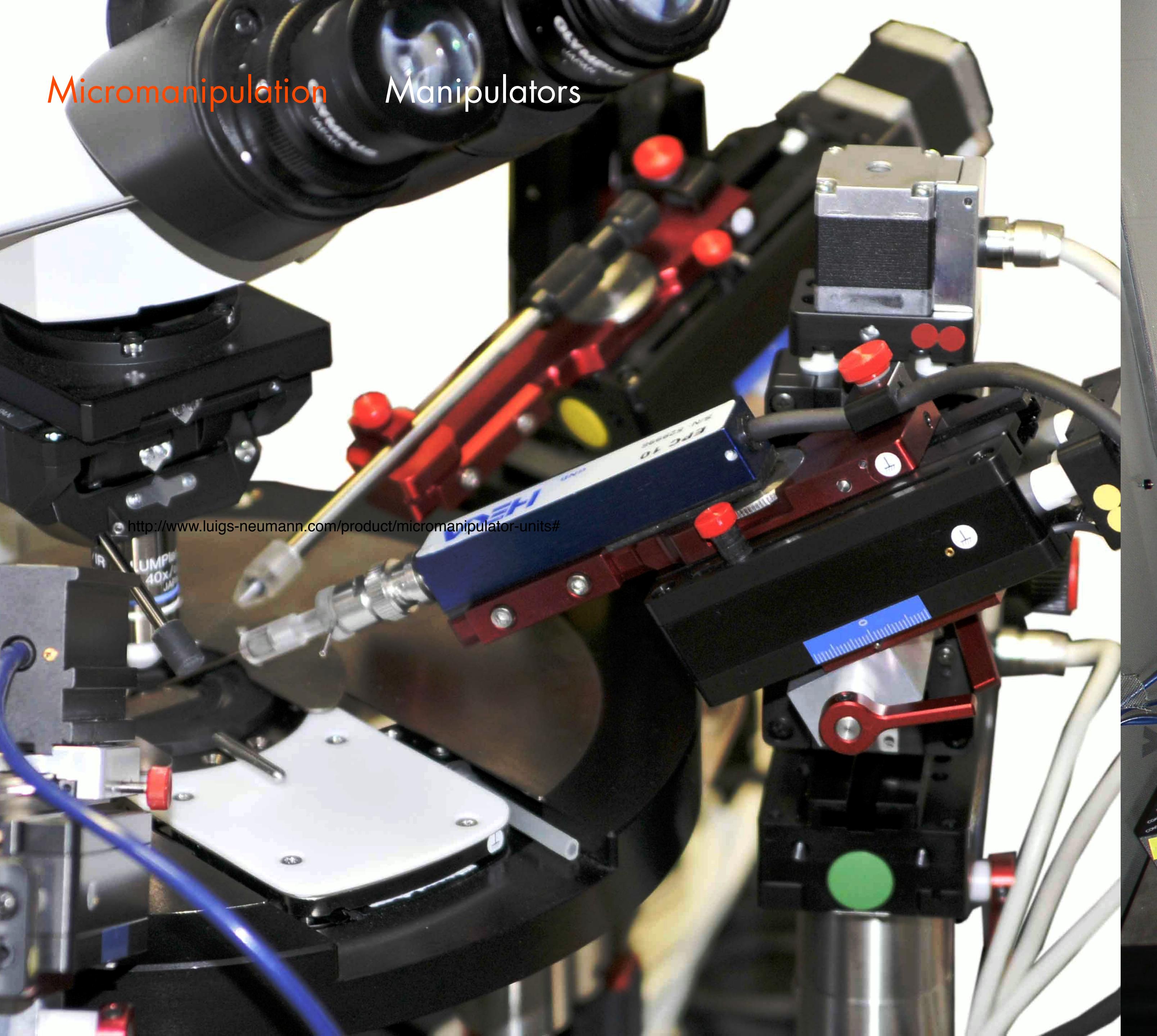
Flexures



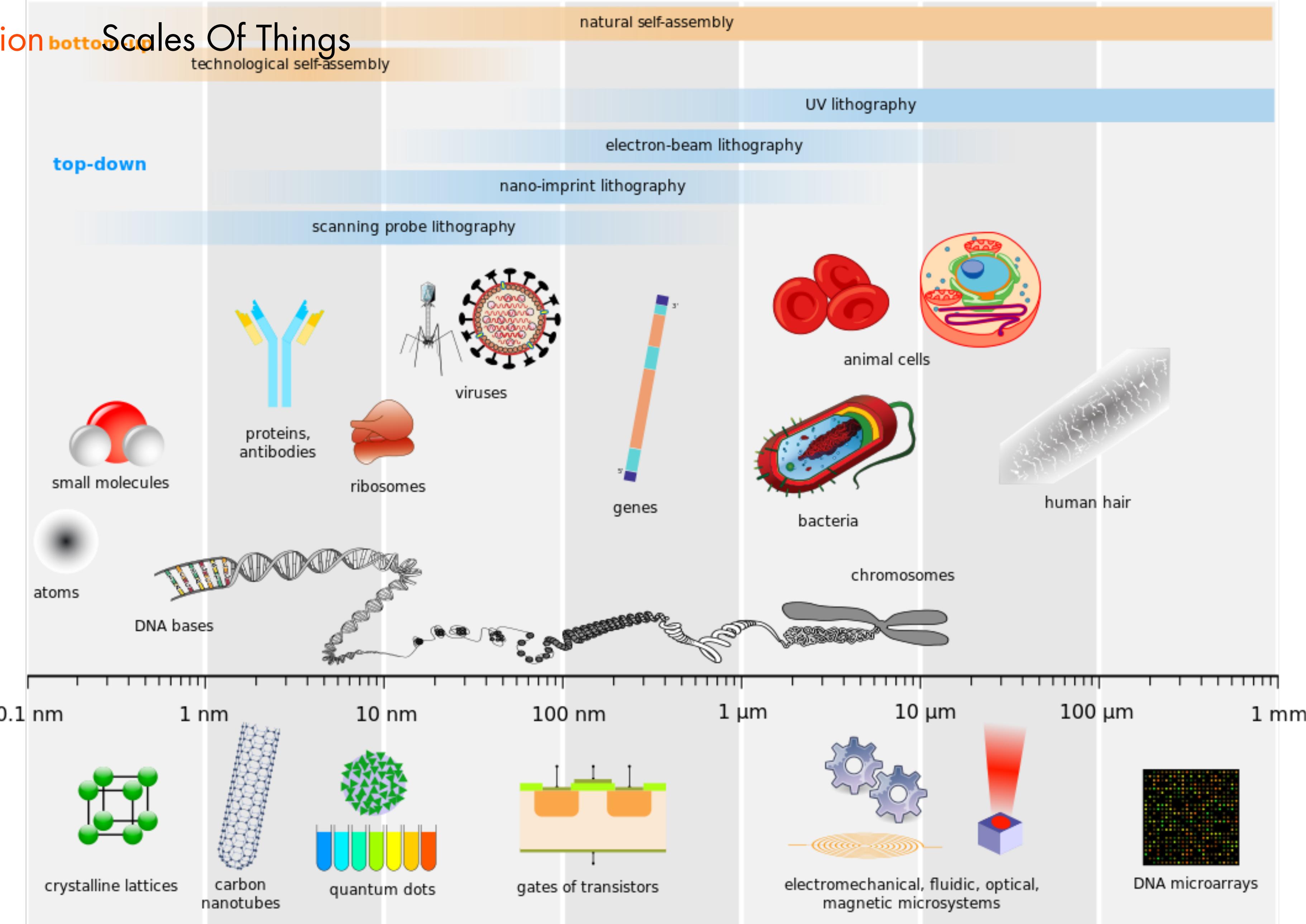
Micromanipulation

Flexures



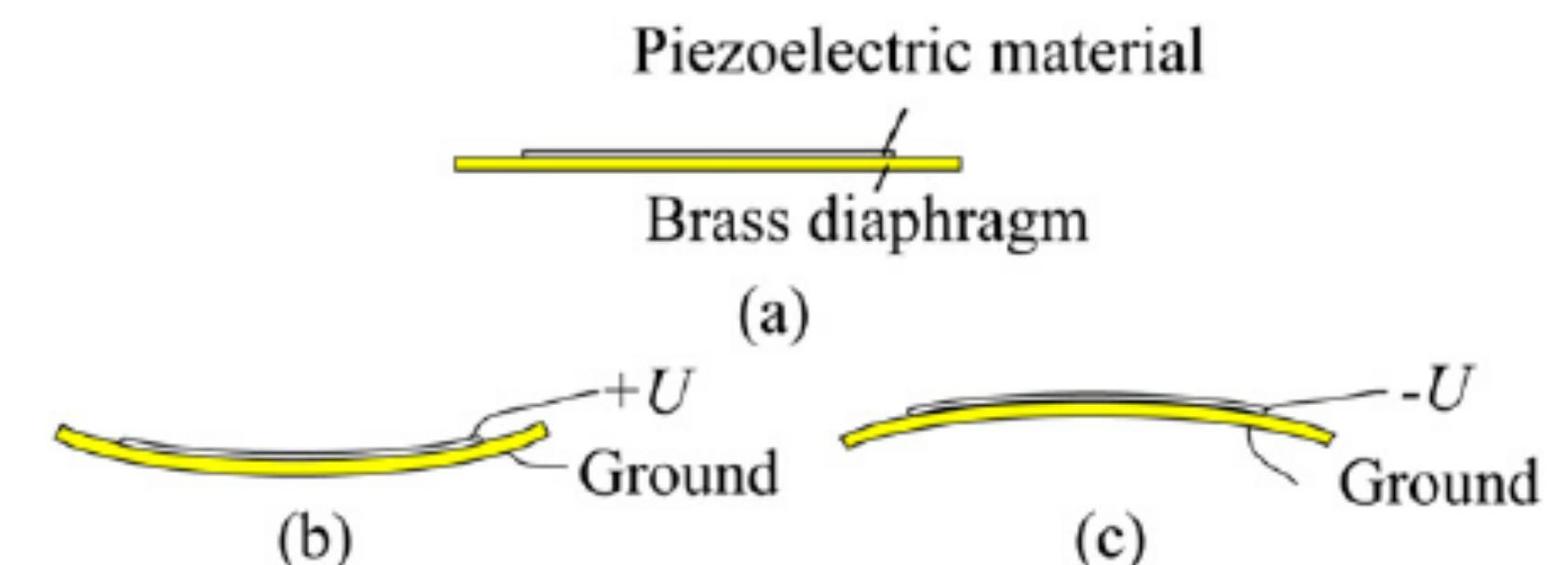
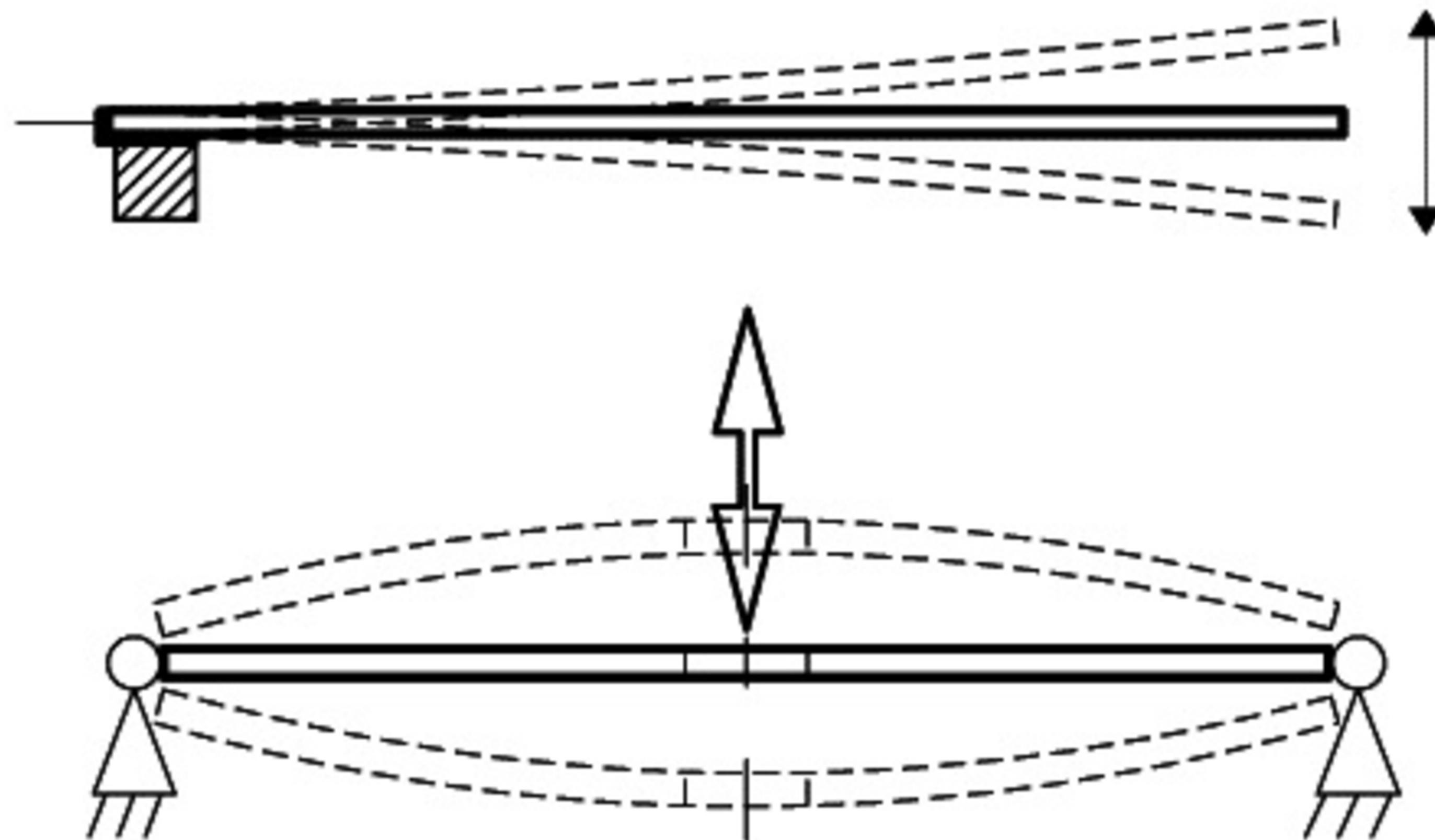


Micromanipulation bottom up Scales Of Things



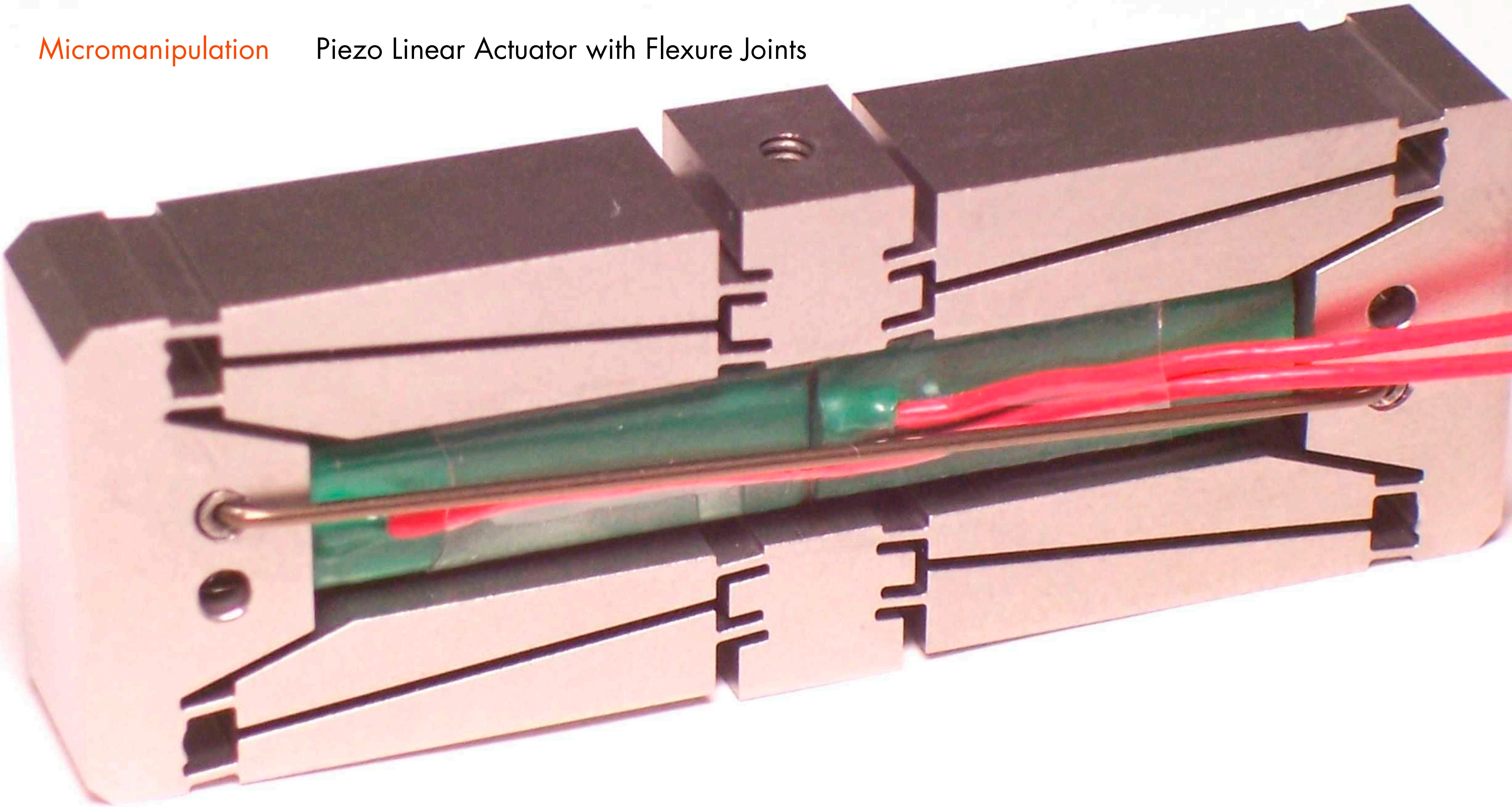
Micromanipulation

Piezo Bender



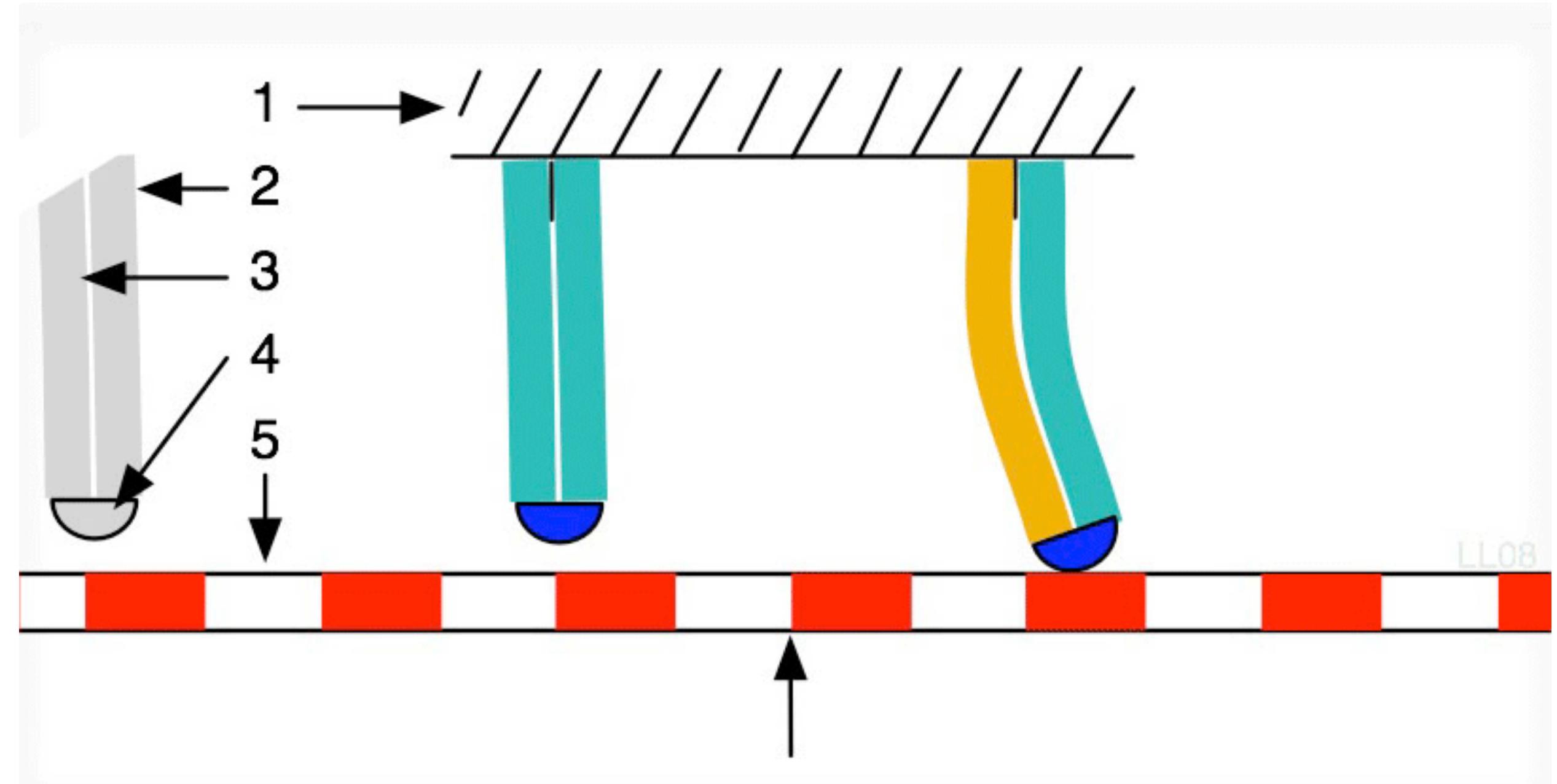
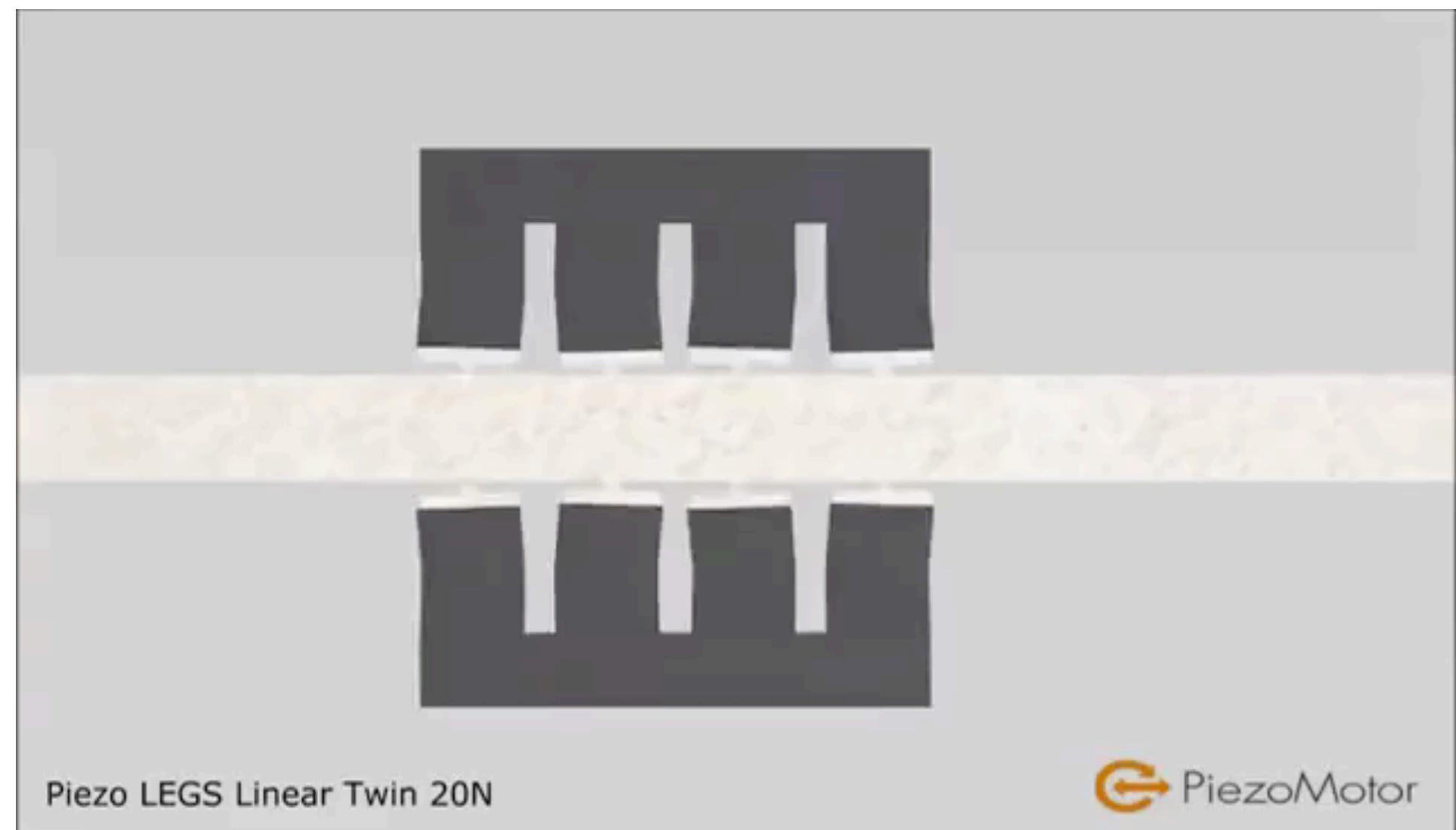
Micromanipulation

Piezo Linear Actuator with Flexure Joints



Micromanipulation

Piezo Legs



Micromanipulation

AFM Piezo Scanner

