



## AFM-kit

Development of a kit for building from scratch an educational *(but decently performing - i.e. usable)* AFM.

# Building AFM is the best way to understand how it "really" works.

## initial tasks

- Define minimum performance of the instrument
- Consider different aspects: mechanical support, actuators, detection electronics, feedback and software.

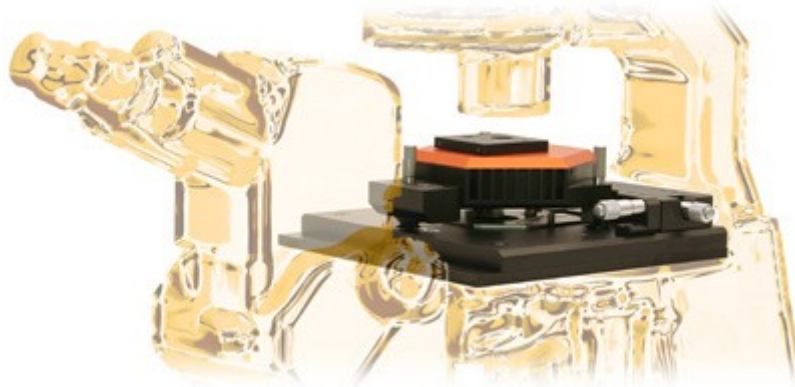
## Inputs from other activities

Practical notes.

Virtual tools

# An example of low cost AFM: FLEX afm

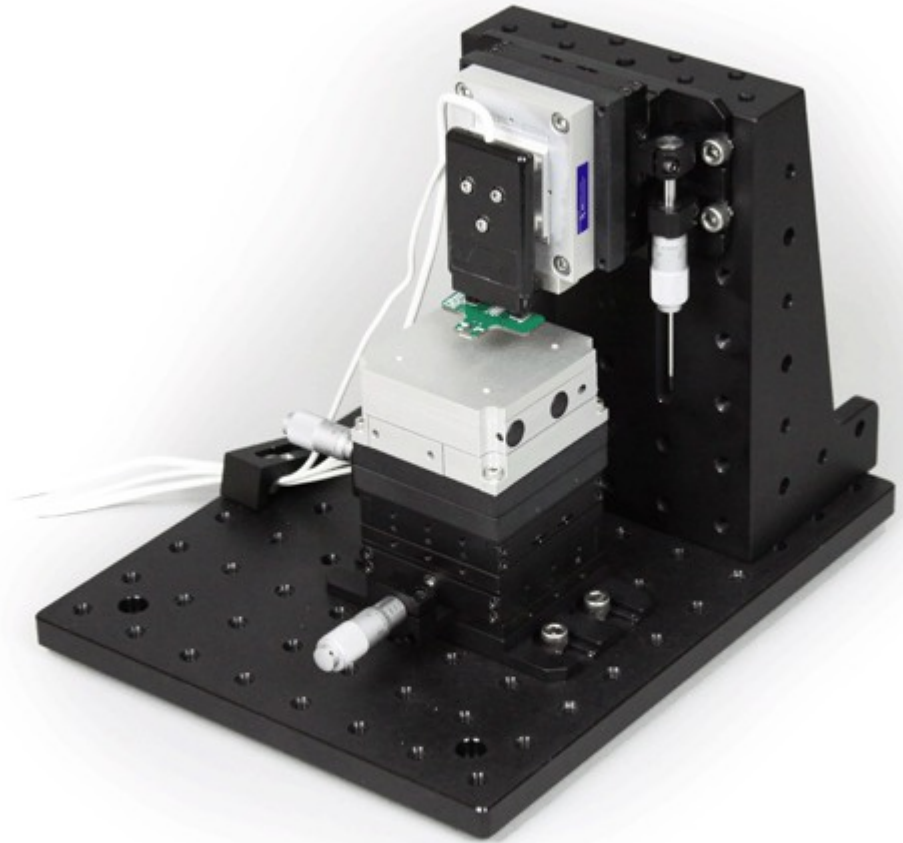
- The Nanosurf® EasyScan 2 FlexAFM
- Liquid ready AFM for the life sciences



# SPM-M Kit from Mad City Lab

- XY movement of sample, 200 $\mu$ m
- Z movement of probe, 30 $\mu$ m
- Akiyama probes

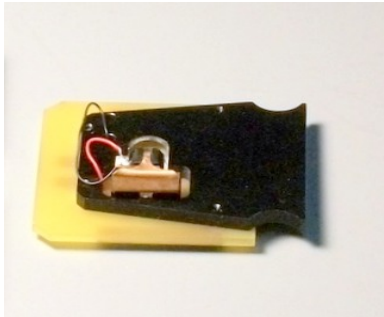
MadPLL® controller is a digital phase lock loop (PLL) controller + software for resonant probe ( Akiyama probe or tuning fork)



*AFM constructed from the SPM-M Kit  
Breadboards, manual XY, and manual Z positioners not included*

# AFM kit from AFMWorkshop

AFMWorkshop  
<http://www.afmworkshop.com/>



**Atomic Force Microscope Kit**  
With this kit it is possible to construct a high powered atomic force microscope. Included with the kit are all of the parts for constructing the TT-AFM, a computer, monitor, probes and a reference standard. (\$25,950.00)

# MIT 20309 Atomic Force Microscope

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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## Biological Engineering II: Instrumentation and Measurement

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**Instructor(s)**  
Maxim Shusteff  
Prof. Peter So  
Prof. Scott Manalis

**MIT Course Number**  
20.309 / 2.67 SJ / 20.409J

**As Taught In**  
Fall 2006

**Level**  
Undergraduate / Graduate

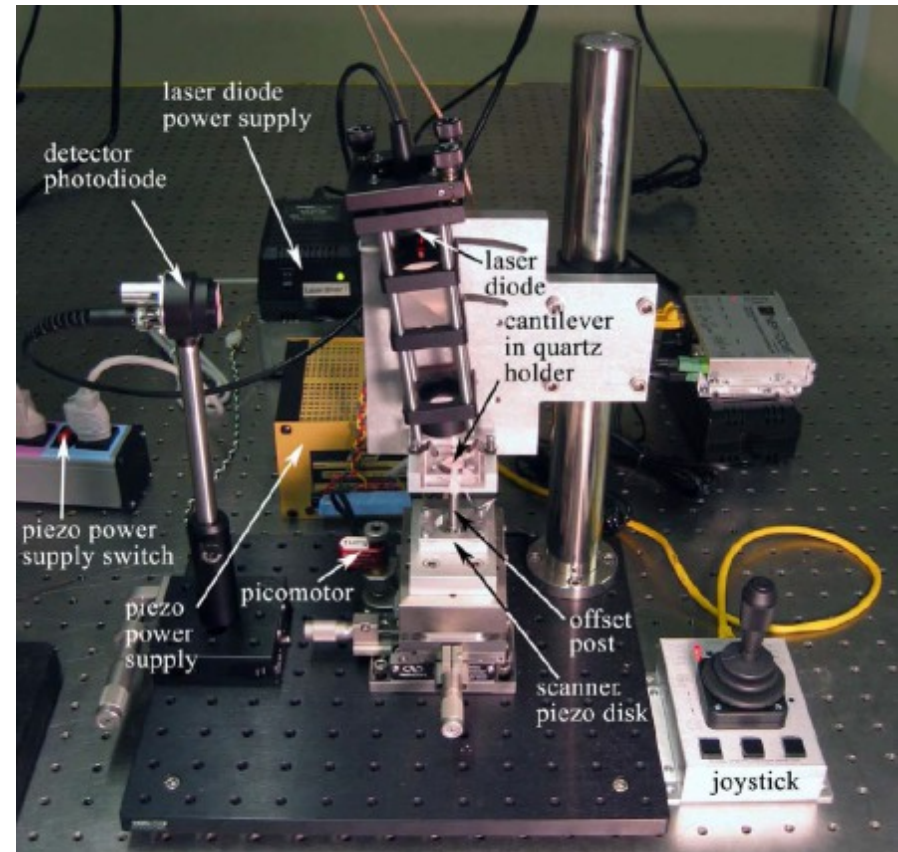
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In the 20.309 lab, Justin Lo focuses the laser source of an atomic force microscope (foreground), while Andrzej Wołoszynski adjusts the sample mounted in an optical trap (background). (Photo by Mr. Maxim Shusteff.)

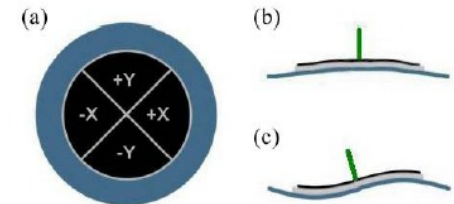
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force detection → interdigital interferometer



scanner → buzzer

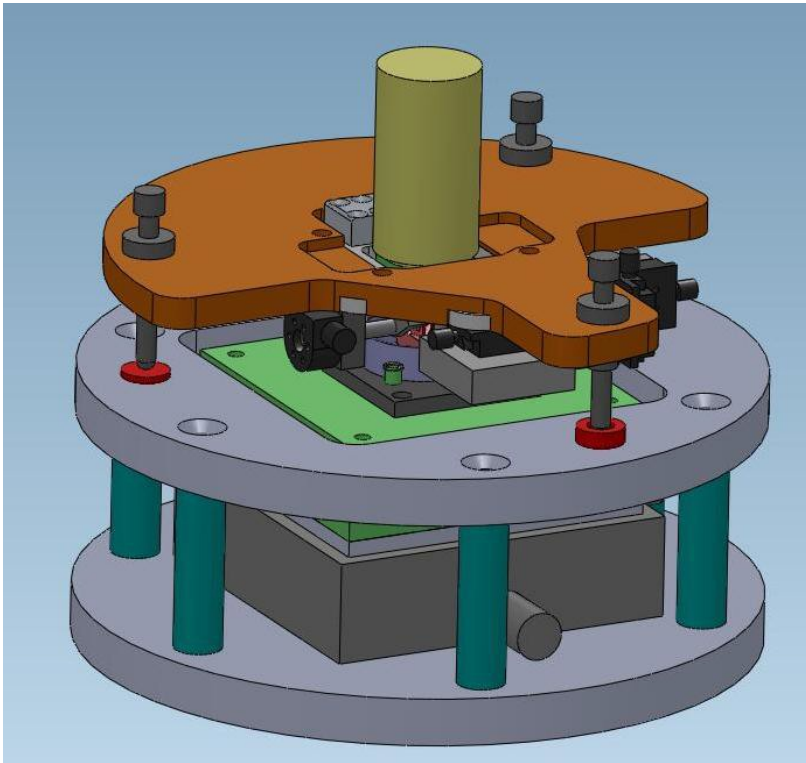


# AFM Subsystems

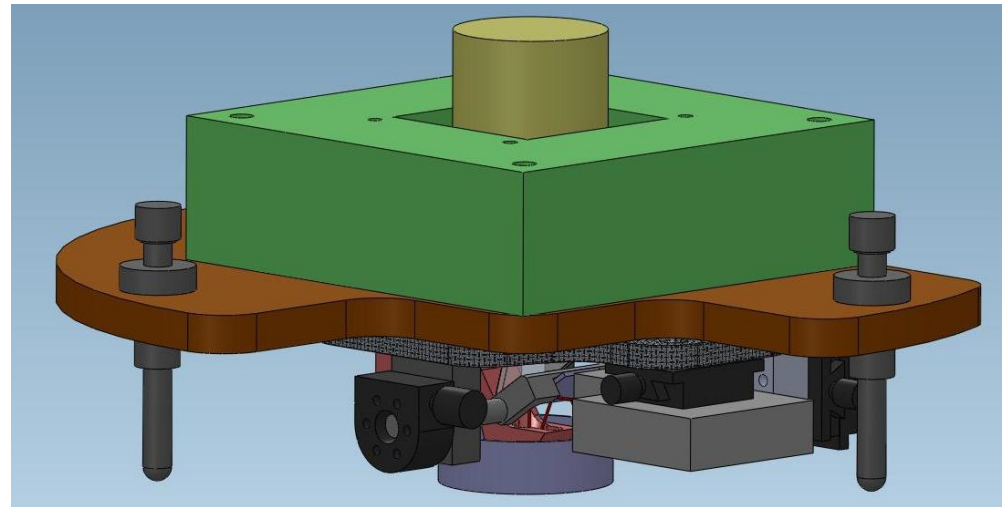
- **HEAD** Head mechanics, piezo actuators, probe holder, sample holder, force detection optics.
- **ANALOG ELECTRONICS** quadrant detector, laser supply, signals for tapping
- **DIGITAL ELECTRONICS** AD/DA, data acquisition, feedback
- **CONTROL SOFTWARE**
- **IMAGE PROCESSING SOFTWARE**



# Mechanical Head Concept Design Example



- XY scanner (sample)
- Z scanner (probe)



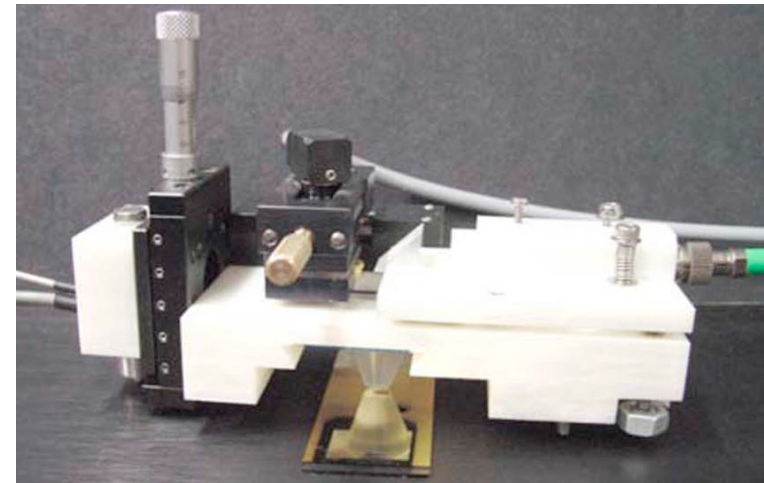
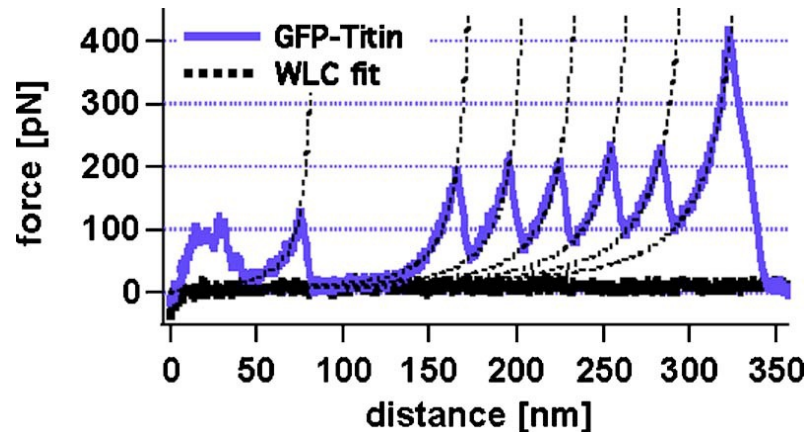
- XY Z scanner (probe)

Lorenzo Barni Phd Tesis Mechanical Engineering University of Florence 2009



# Print your atomic force microscope

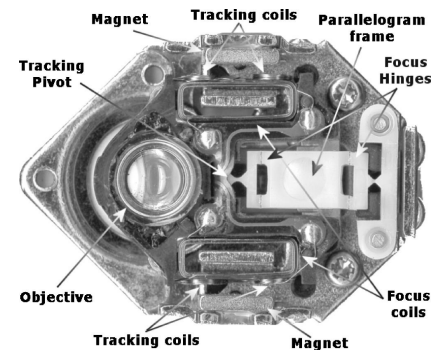
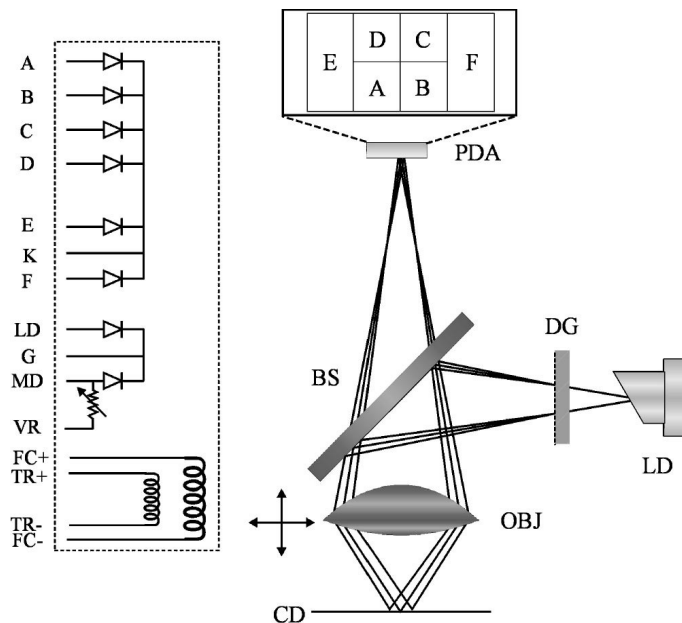
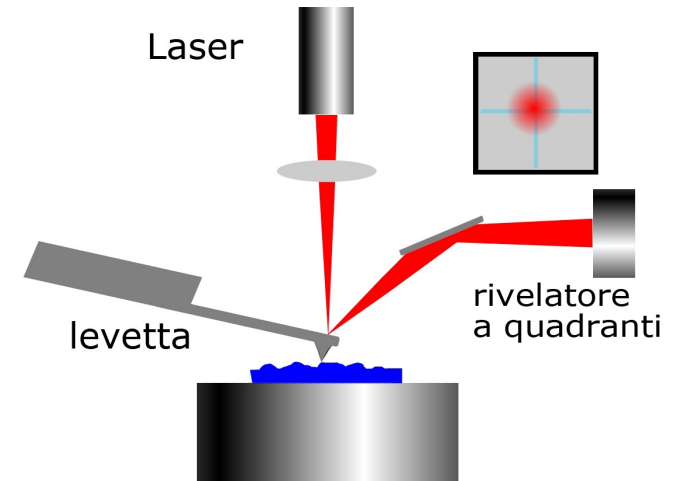
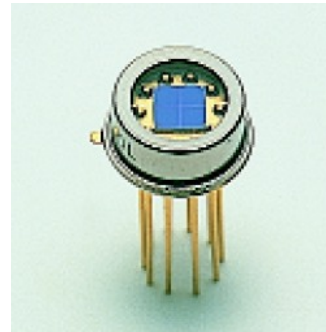
Laser driven rapid prototyping  
design of the printed pieces was  
done in Solidworks software



Ferdinand Kühner, a Robert A. Lugmaier, Steffen Mihatsch, and Hermann E. Gaub  
REVIEW OF SCIENTIFIC INSTRUMENTS 78, 075105 2007

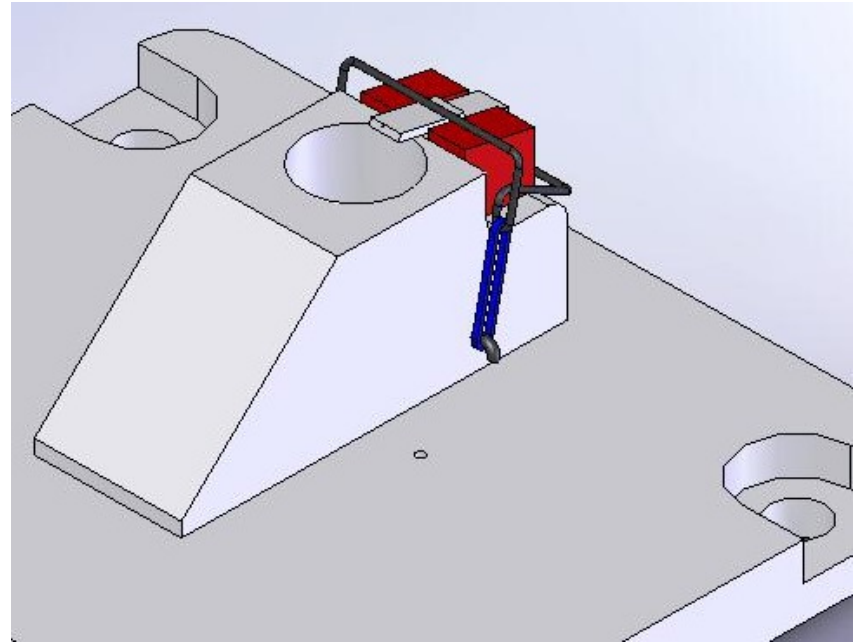
# Force detection method

- Optical Beam Deflection
- Interferometer
- CD or DVD pick-up



# Probe Holder

- easy alignment in air and liquid
- use standard probes
- easy to clean



# Control HW - Software

GXSM Gnome X Scanning Microscopy  
*DSP-based system (4200 \$Can)*



REAL TIME  
*real time pc + AD/DA board*

G. Aloisi, F. Bacci, M. Carlà, D. Dolci, and L. Lanzi “Implementation on a desktop computer of the real time feedback control loop of a scanning probe microscope” Rev. Sci. Instrum. 79 113702 (20089)

RT process directly inside the kernel space  
DAQ board PCI-6221 National Instrument

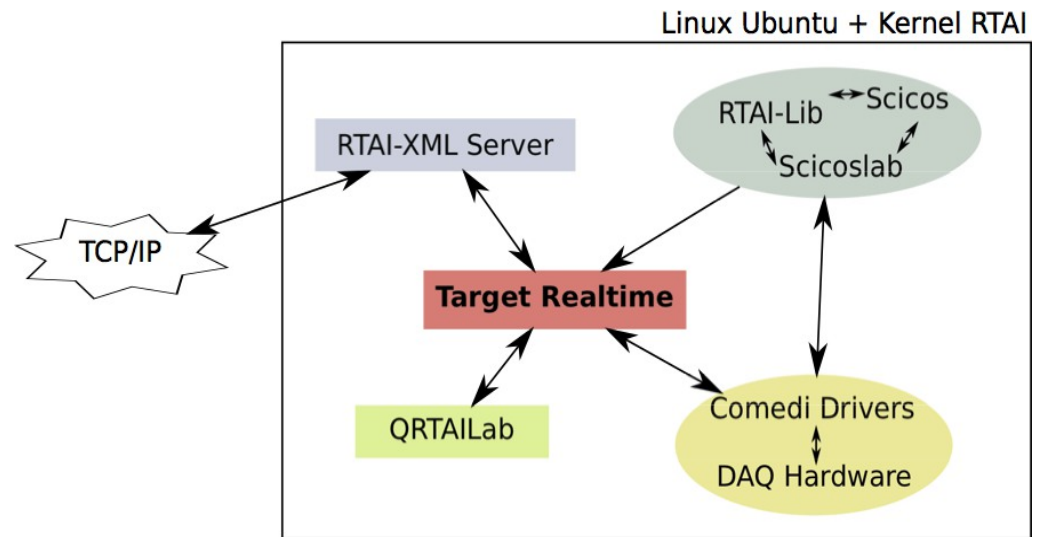
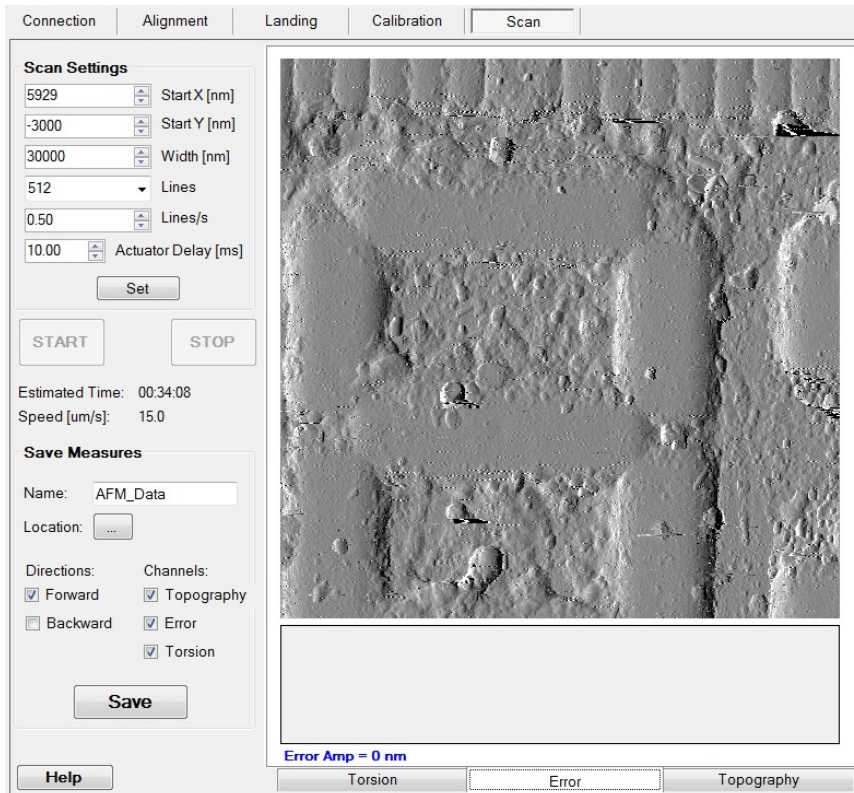
D. Materassi, P. Baschieri, B. Tiribilli, G. Zuccheri “An Open Source/Real-Time AFM Architecture to Perform Customizable Force Spectroscopy” Rev. Sci. Instrum. 80, 084301 (2009)

Realized using SIMULINK™ visual programming language,  
, the real-time code is automatically generated  
by MATLAB REAL-TIME WORKSHOP™.

Michele Basso, Roberto Bucher, Marco Romagnoli and Massimo Vassalli  
“Real-Time Control with Linux: A Web Services Approach”

LINUX RTAI

# RTAI, Scicoslab and RTAI-XML



# Image processing software

## WSxM v4.0 Beta 6.3

<http://www.nanotec.es/>

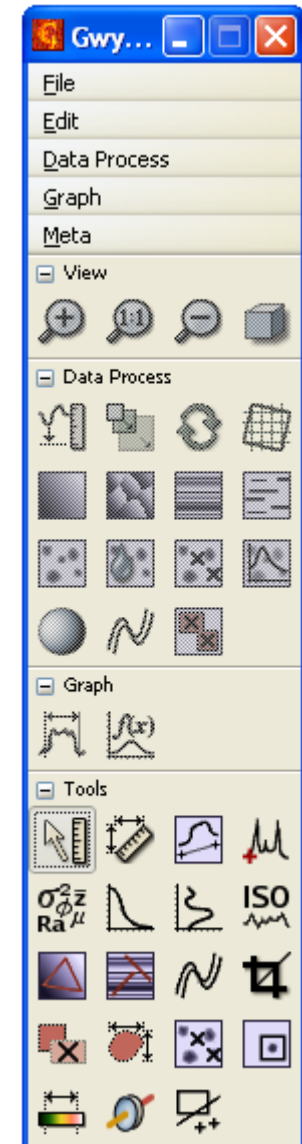
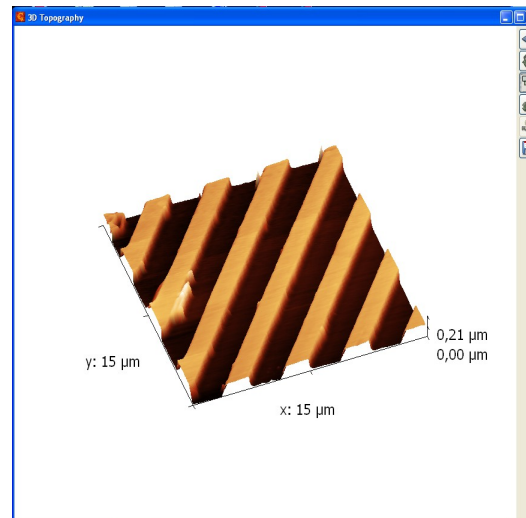
I. Horcas, R. Fernandez, J.M. Gomez-Colchero, J. Gomez-Herrero and A. Sanchez. Sci. Instrum. 78, 013705 (2007)



## Gwyddion <http://gwyddion.net> is Free and Open Source software

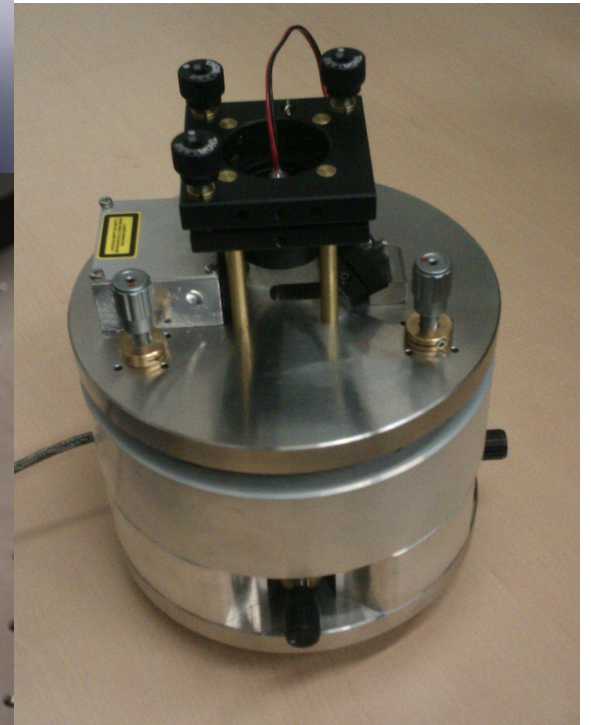
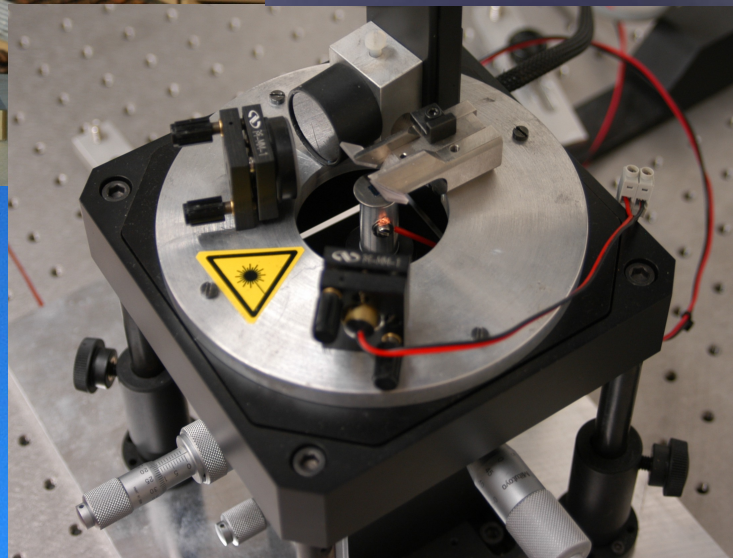
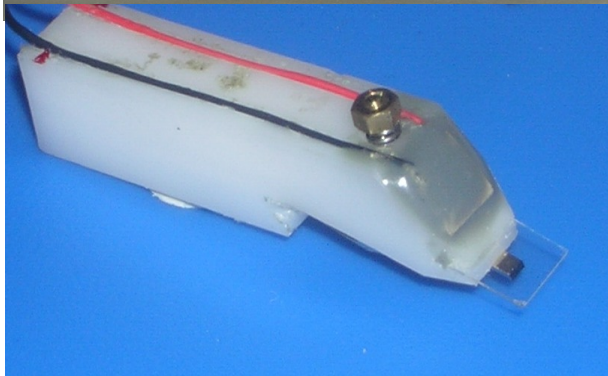
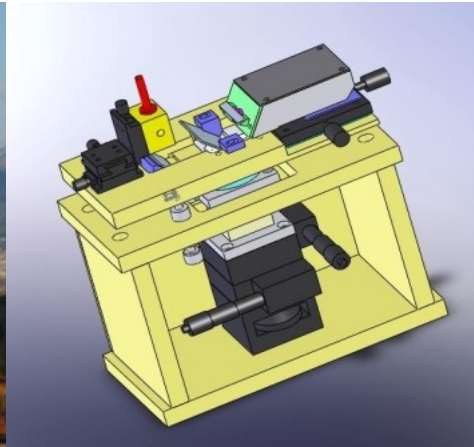
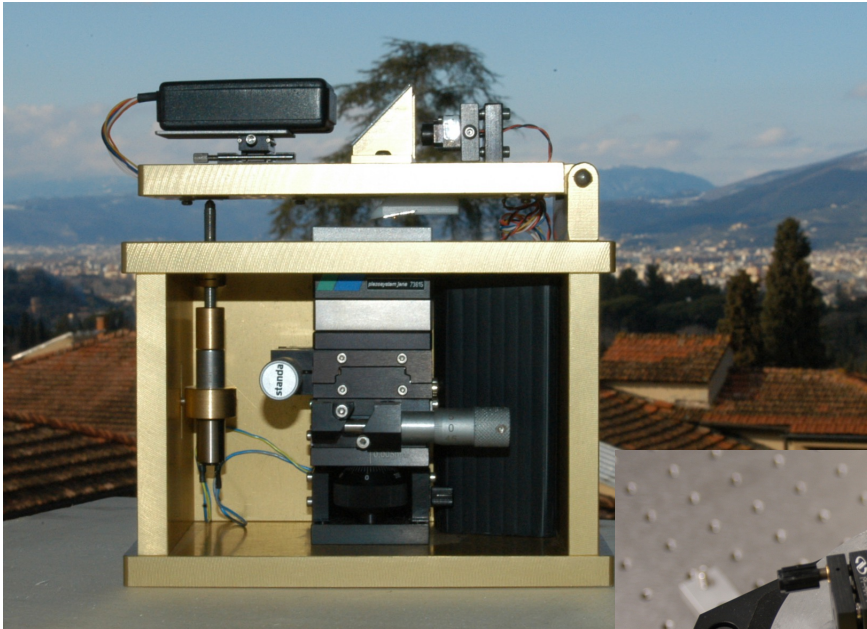
Petr Klapetek  
Czech Metrology Institute, Brno  
Czech Republic

David Nečas (Yeti)  
Plasma Technologies  
CEITEC – Central European Institute of Technology  
Masaryk University, Brno  
Czech Republic





# AFM in Florence





# AFM KIT: REQUIREMENTS

**Operating modes:** contact tapping

**Force spectroscopy**

**Optical access:**  
capable to operate on an inverted optical microscope  
(Daniel Navajas)

?

Spring constant calibration

?

Operate in liquid

# Useful links.

## **MIT OPEN COURSE**

<http://ocw.mit.edu/courses/biological-engineering/20-309-biological-engineering-ii-instrumentation-and-measurement-fall-2006/index.htm>

<http://ocw.mit.edu/courses/biological-engineering/20-309-biological-engineering-ii-instrumentation-and-measurement-fall-2006/labs/module2.pdf>

## **SPM OPEN SOURCE CONTROLLER**

<http://www.softdb.com/spm-products.php>

## **MAD CITY LAB**

<http://www.madcitylabs.com/spmmkit.html?gclid=CIWE6KTikLYCFePHtAodJTUADA>

## **FIRST-Sensor 4Q detector**

[http://www.first-sensor.com/sites/www.first-sensor.com/files/downloads/datasheets/optical\\_sensors/modules/evaluation\\_modules/evaluation\\_boards/qp50-6sd2-500741\\_0.pdf](http://www.first-sensor.com/sites/www.first-sensor.com/files/downloads/datasheets/optical_sensors/modules/evaluation_modules/evaluation_boards/qp50-6sd2-500741_0.pdf)

## **STM project and Disk Scanner**

[http://www.geocities.com/spm\\_stm/index.html](http://www.geocities.com/spm_stm/index.html)

## **AFM workshop**

<http://www.afmworkshop.com/>