High Speed Atomic Force Microscope
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High Speed Atomic Force Microscope

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Summary

Atomic Force Microscope (AFM) is now a common tool for material analysis in the academic and industrial areas because it enables non-destructive high-resolution images of nanometric objects. However, a main drawback is the slow scan rate that hinders many potential applications. Recently, breakthroughs have been achieved in AFM sensors based on MEMS technology, allowing to extend AFM operation in terms of measurement bandwidth and data acquisition. The present work focusses on developing an electronic controller for AFM featuring the wide bandwidth and the fast data processing rate required to enable the exploitation of the full potential of MEMS AFM sensors.

Software architecture

PC – LabVIEW 2016, QMH project

UI@ 10 ms
R/W network streams from RT
Unbundle data
Convert data to physical units (m,V)
Averaging per pixel

UI@ 100 ms
Display scaled data
Display scan images

UI management
Save image files
Control USB motor for approach

Real-Time Controller – LabVIEW RT, QMH model

RT@ 5 ms non determin.
R/W stream to UI

RT@ 1 ms deterministic
Read data from FPGA

FPGA – LabVIEW FPGA

Z control loop @1µs pipelining
Probe signal acquisition
PID calculation with gain schedule
Piezo Z command (20-bit word to external DAC)

Scan control @10µs or more
Scan X, Y via Analog Outputs
Read X, Y position sensors (AIs)
Watchdog @40MHz

High frequency AFM probes (MEMS technology)

AFM probes used in the present work were developed at IEMN-CNRS (Lille, FRANCE) and are now available from Vmicro SAS. A silicon ring holding a nanotip vibrates according to the elliptical resonance mode shape at about 13 MHz. Capacitive electromechanical transducers are integrated for driving and sensing the nanotip vibration. Typical measurement resolutions are 1.5 nm/√Hz in displacement and 0.5 pN/√Hz in force.

Software performance

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<th>Small image 1k pixels</th>
<th>Biggest image 3M pixels</th>
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<tr>
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<tr>
<td>Binary file size</td>
<td>47 KB</td>
<td>140 MB</td>
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Contact and informations at: https://www.laas.fr/projects/olympia
This work is supported by the projects : ANR OLYMPIA ANR-15-CE26-0001

High Speed AFM setup at LAAS CNRS, Toulouse (France)

High Speed Atomic Force Microscope

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