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To cite this version:

HAL Id: hal-01529673
https://hal.laas.fr/hal-01529673
Submitted on 31 May 2017

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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 focuses 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.

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

Scan duration
- Small image: 1K pixels
  - 0.02s (50 images/s)
- Biggest image: 3M pixels
  - 60s

Binary file size
- Small image: 1K pixels
  - 47 KB
- Biggest image: 3M pixels
  - 140 MB

Contact and information at: https://www.laas.fr/projects/olympia

This work is supported by the projects: OLYMPIA (ANR-14-CE26-0003) - CNRS DYNAMIC

AFM mode
- (a) Image: 3 x 1 μm (256 x 256 pixels) acquired in 60 s.
- (b) Images forward and backward 200 x 200 μm (0.08 x 0.08 inch) acquired in 5 s.
- The topographic contrast is due to elasticity contrast of copolymers strips.

Image of graphitic HOPG steps in 3D AFM mode
- (a) Image: 2.5 x 2.5 μm (512 x 512 pixels) acquired in 15 s.
- (b) Image: 1 x 1 μm (200 x 200 pixels) acquired in 40 s.
- (c) Image: 1 x 1 μm (200 x 200 pixels) acquired in 20 s.

Topography images of diblock copolymers in 3D AFM mode
- (b) image: 3 x 1 μm (256 x 256 pixels) acquired in 60 s.
- (c) images forward and backward 200 x 200 μm (0.08 x 0.08 inch) acquired in 5 s.