Outcomes of and materials for two university-level courses on atomic force microscopy (AFM)

N.A. Burnham, Departments of Physics and Biomedical Engineering, Worcester Polytechnic Institute, Worcester, MA USA

Abstract

The outcomes of and materials for undergraduate and graduate courses on Atomic Force Microscopy (AFM) are described. The courses have been well received by students, almost half of whom go on to use their AFM skills in subsequent studies or professions. Course materials for labs and in-class exercises are available upon request from the author in order to promote further development of AFM courses at other institutions. It is hoped that more AFM courses will draw more students into the intriguing world of nanoscience.

Support from both WPI and NSF NUE Award #0406687 is gratefully acknowledged. Details were published in J. Nano Education **5**, 109-114 (2013).

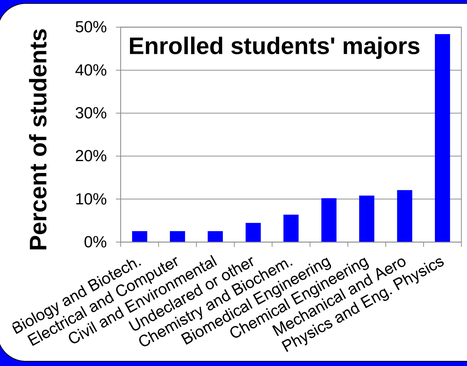
Course objectives:

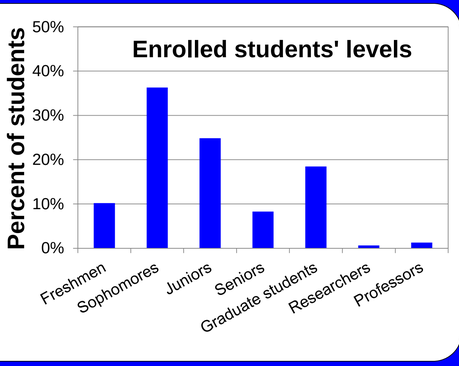
- To become competent in the use of AFMs and in the interpretation of AFM data
- To learn how physics applies to AFMs
- To gain an understanding and appreciation of scientific research
- To develop the ability to write a good lab report

The seven units of the course are:

- Fundamentals of imaging
- Difficulties of imaging
- Other SPMs and operational modes
- Probe and scanner calibration
- Force-curve mechanics
- Tip-sample interactions
- A glimpse at current research

Enrollment:



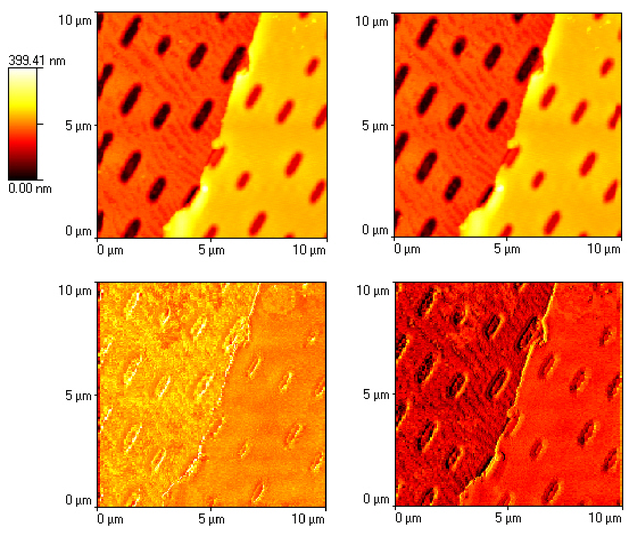


Outcomes:

- 157 students in eight renditions of undergraduate course, 24 students in three renditions of the graduate course in the period 2001-2013
- 45 % of students go on to use AFM in further studies or careers
- Overall quality of course as rated by students is 4.7/5.0 over last seven offerings

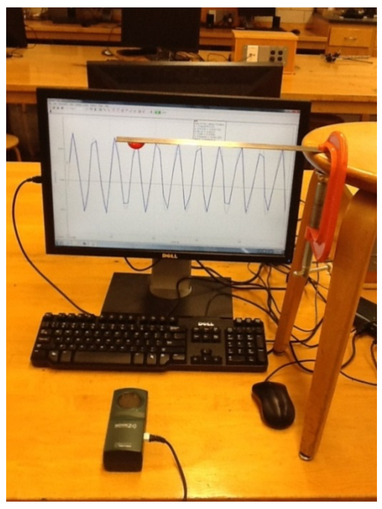
Three different types of labs

Instrument labs



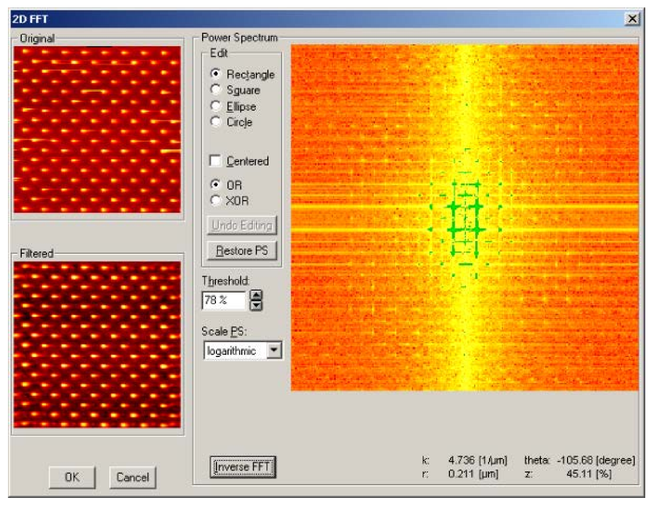
Left: The upper two images are the forward and reverse topography of an exfoliated pressed CD, the lower two reveal the lateral forces. The students acquire these data in the third instrument lab, after being taught about the forces acting on the tip.

"Macro" labs



Center: Students perform measurements with a macroscopically sized cantilever to better understand the behavior of the cantilever in the AFM. The data on the screen display the position of the tip of the cantilever as a function of time.

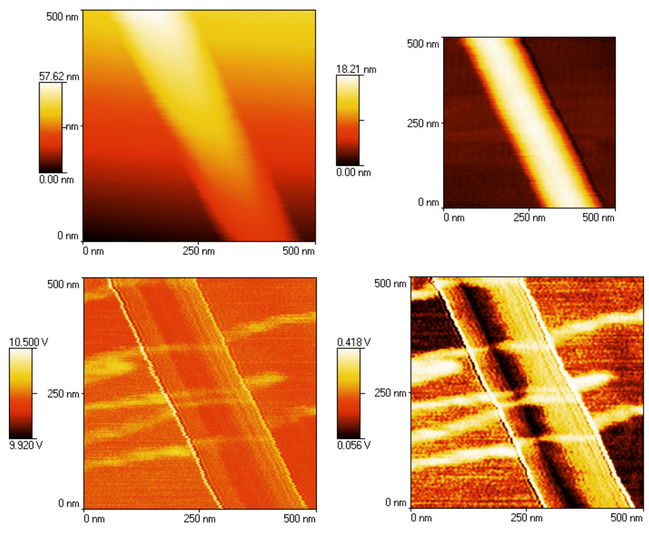
Computer labs



Right: Computer labs help the students understand challenging concepts. Shown here is fourier threshold filtering of a streaky image of a calibration grating. Only the green-highlighted peaks in the 2D FFT are retransformed into the filtered image.

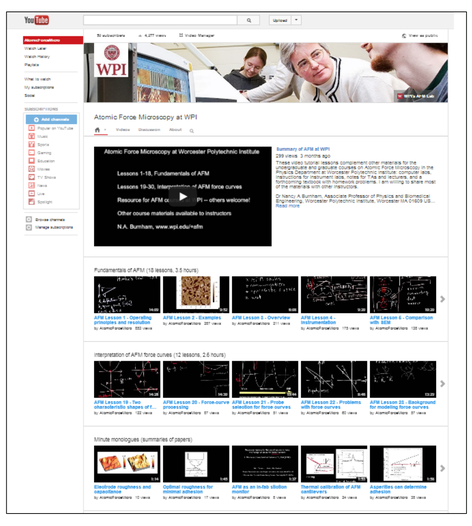
Other course materials

In-class writing exercises



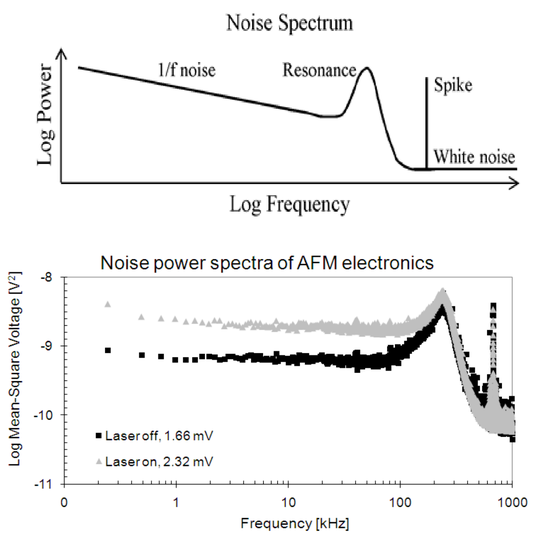
Left: Students are given a woefully bad multi-part figure to critique. They are then shown the improved version. These images are topographic (top) and shear-amplitude (bottom) forward and reverse images of a carbon nanotube on graphite.

YouTube videos



Center: Much of the content of the course has been placed at YouTube/AtomicForceMicro, freeing up class time for questions, discussion, and the six in-class writing exercises. There are thirty short videos totaling over six hours.

Forthcoming textbook with homework



Right: A textbook with homework problems is still under development. Concepts, example data, and mathematics are presented, all with a view to improve the reader's understanding of the physics of AFM. Here, a sketch and data of noise spectra are shown.

An intensive short course on atomic force microscopy

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N.D. Spencer, Laboratory for Surface Science and Technology, Swiss Federal Institute of Technology Zurich

Abstract

An intensive course on Atomic Force Microscopy (AFM) will be taught at ETH Zurich in the summer of 2015, based on successful AFM courses at Worcester Polytechnic Institute. The outcomes of and materials for undergraduate and graduate courses on Atomic Force Microscopy (AFM) are described here. The courses have been well received by students, almost half of whom go on to use their AFM skills in subsequent studies or professions. Course materials for labs and in-class exercises are available upon request from the author in order to promote further development of AFM courses at other institutions. It is hoped that more AFM courses will draw more students into the intriguing world of nanoscience. Support from both WPI and NSF NUE Award #0406687 is gratefully acknowledged. Details were published in J. Nano Education **5**, 109-114 (2013).

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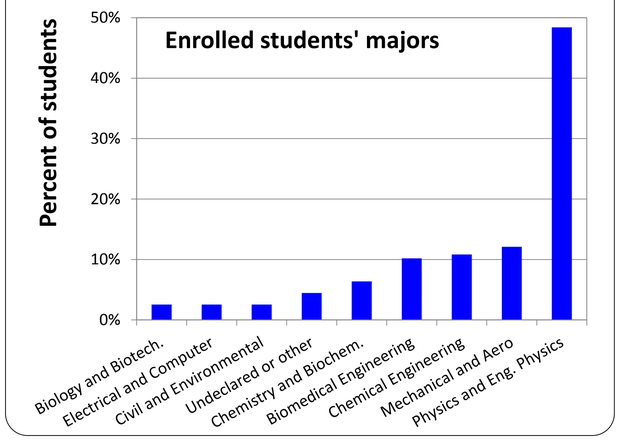


Outcomes:

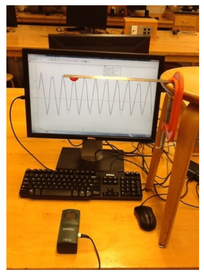
- 173 students in nine renditions of undergraduate course, 36 students in four renditions of the graduate course in the period 2001-2015
- 45 % of students go on to use AFM in further studies or careers
- Overall quality of course as rated by students is 4.7/5.0 over last seven offerings

Three different types of labs

Instrument labs

Left: The instrument labs are broken into six two-hour sessions. After preparting for the first lab by watching three video tutorials, the students take a quiz and are collecting contact-mode images by the end of the first session. (Image credit: Nanosurf NaioAFM Operating Instructions)

“Macro” labs



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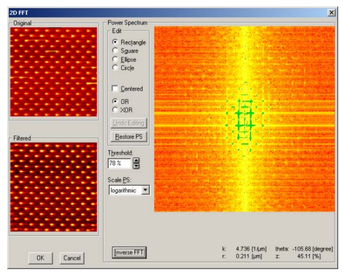

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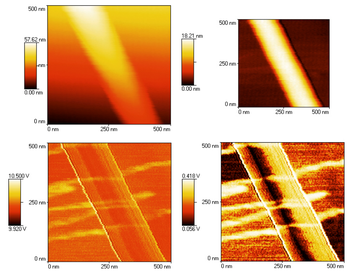

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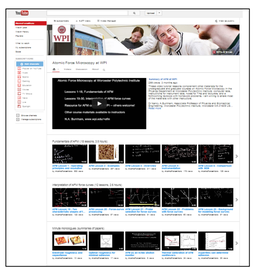

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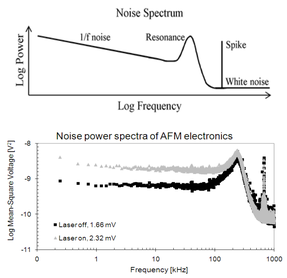
Forthcoming textbook



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