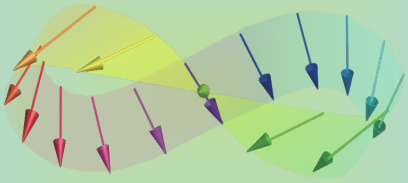
Information Storage and Spintronics
Practical Session 3

~ Magnetic Force Microscopy ~



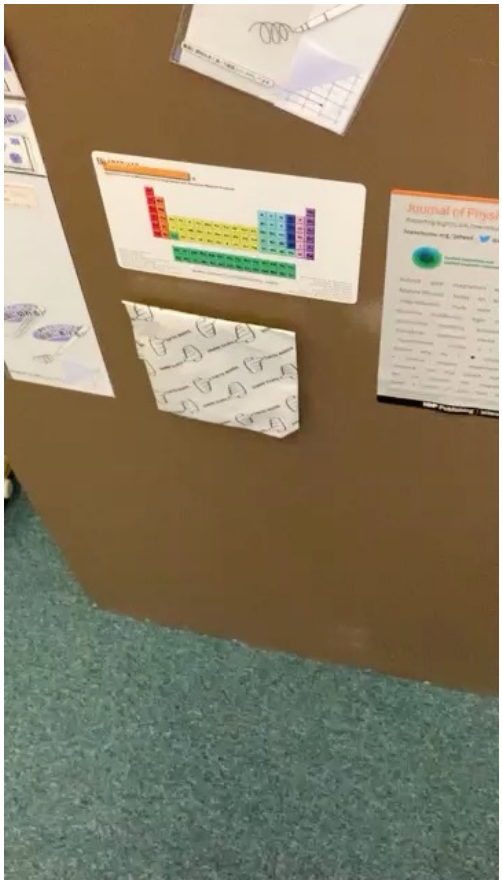
Atsufumi Hirohata

Department of Electronic Engineering

THE UNIVERSITY of York

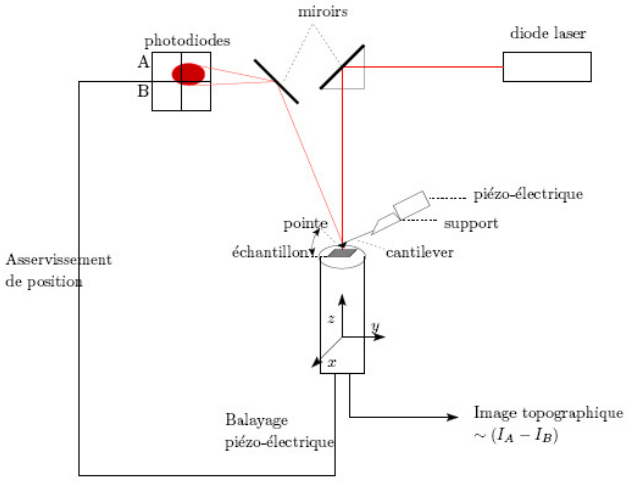
13:00 Wednesday, 26/October/2022

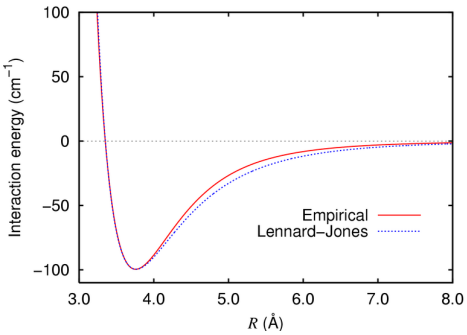
Magnetic Domain Observation

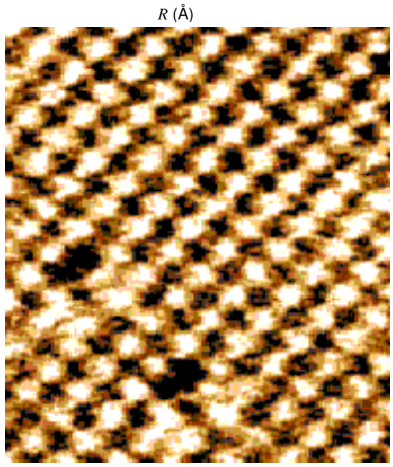


Atomic Force Microscope (AFM)

In 1985, Gerd Binnig invented atomic force microscopy :





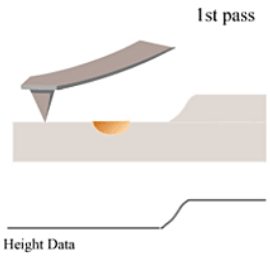


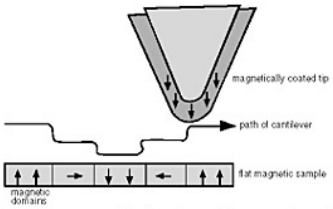
→ Non-conductive surface can be observed.

* http://www.wikipedia.org/

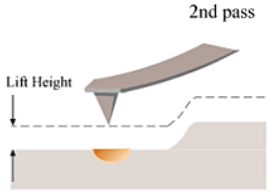
Magnetic Force Microscope (MFM)

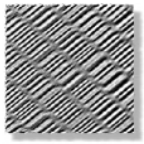
In 1987, a magnetic tip was introduced to observe a : *





MFM maps the magnetic domains of the sample surface.





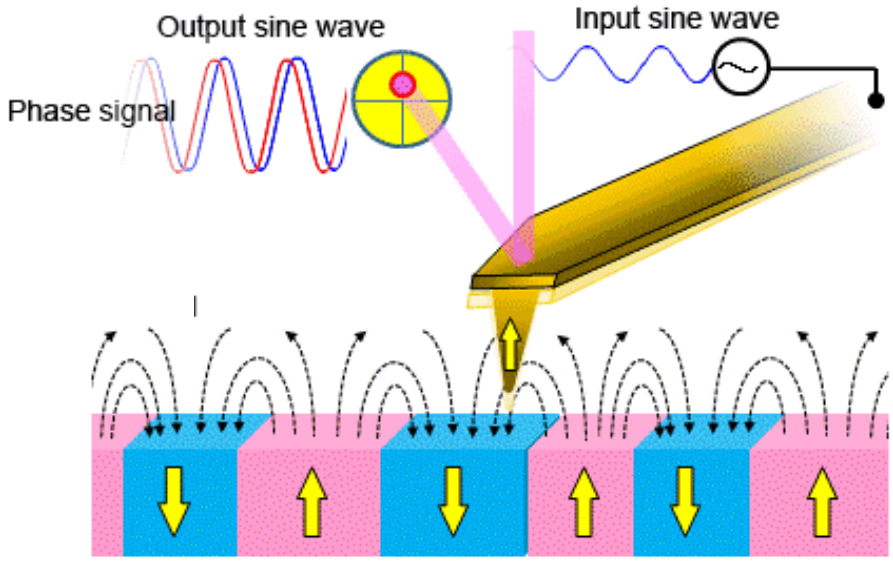
MFM image showing the bits of a hard disk.
30µm. scan

→ By subtracting surface morphology, are observed.

* Y. Martin, H. K. Wickramasinghe, *Appl. Phys. Lett.* **50**, 1455 (1987).
** http://www.veeco.com/

MFM Operation

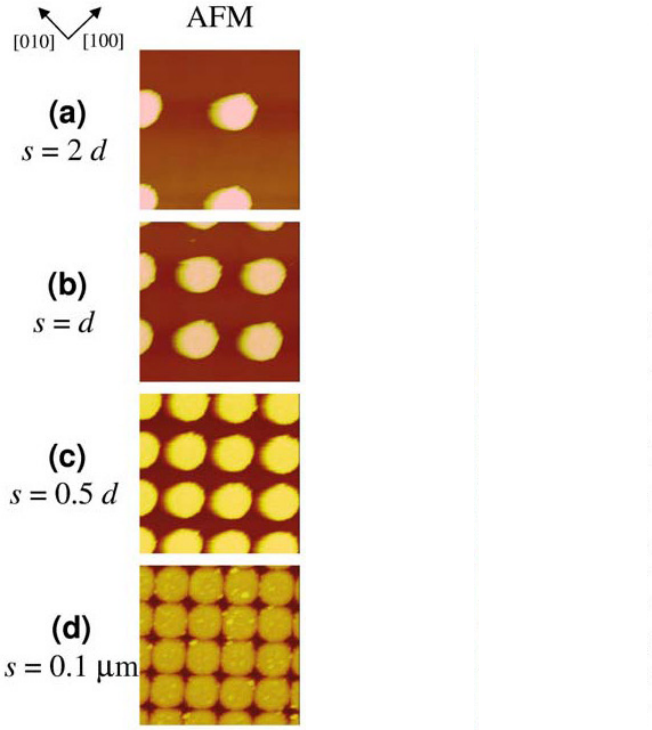
The displacement of the magnetic is detected by ptotodetectors : *



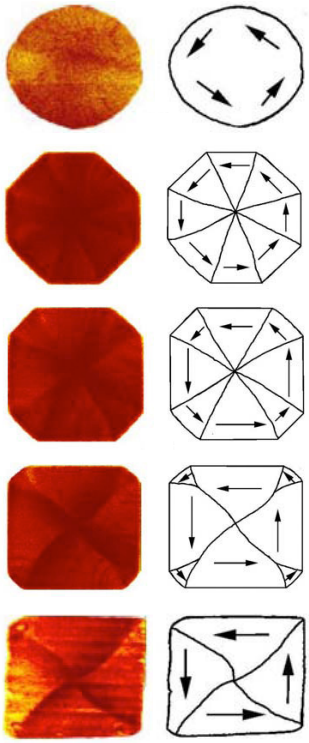
* https://www.hitachi-hightech.com/global/science/technical/tech/microscopes/spm/descriptions/electro/mfm.html

AFM / MFM Images

MFM images can subtract dots morphology :



20 nm thick Fe dots (1 µm diameter)

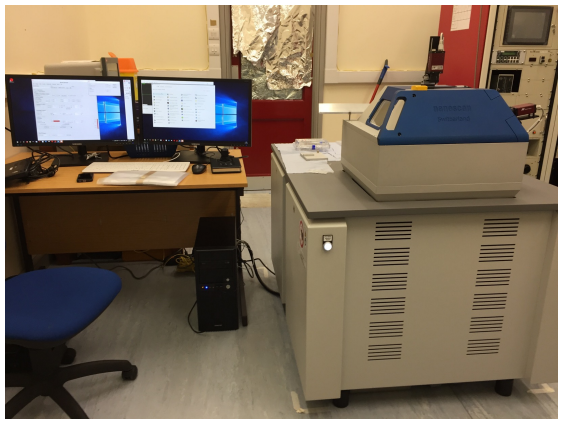


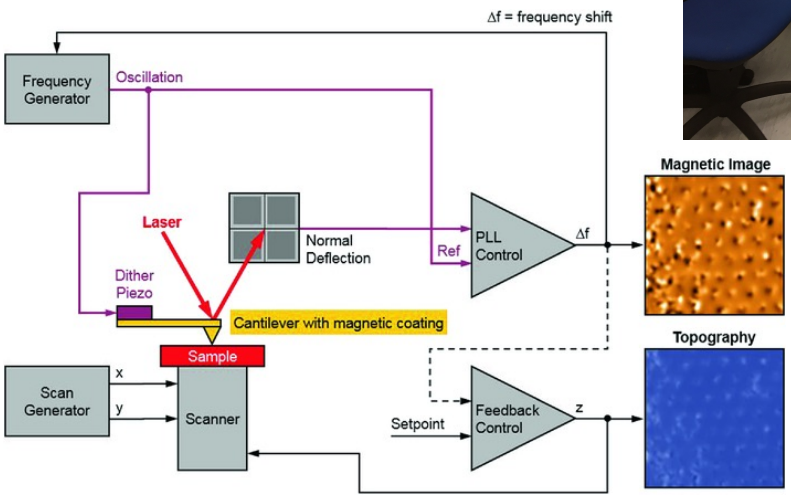
30 nm thick NiFe dots (5 µm)

AFM / MFM Setup

Nanoscan VLS-80 : *

- Modes: atomic force microscope (AFM) & magnetic force microscope (MFM)
- In-plane magnetic field: - 5.5 ~ + 5.5 kOe
- Perpendicular magnetic field: - 2.0 ~ + 2.0 kOe
- Stage temperature: room temperature





* A. Hirohata *et al.*, "Magnetic Force Microscopy for Magnetic Recording and Devices," *in "Electrical Atomic Force Microscopy for Nanoelectronics,"* Umberto Celano (Ed.) (Springer, Berlin, Germany, 2019) p. 231-265.

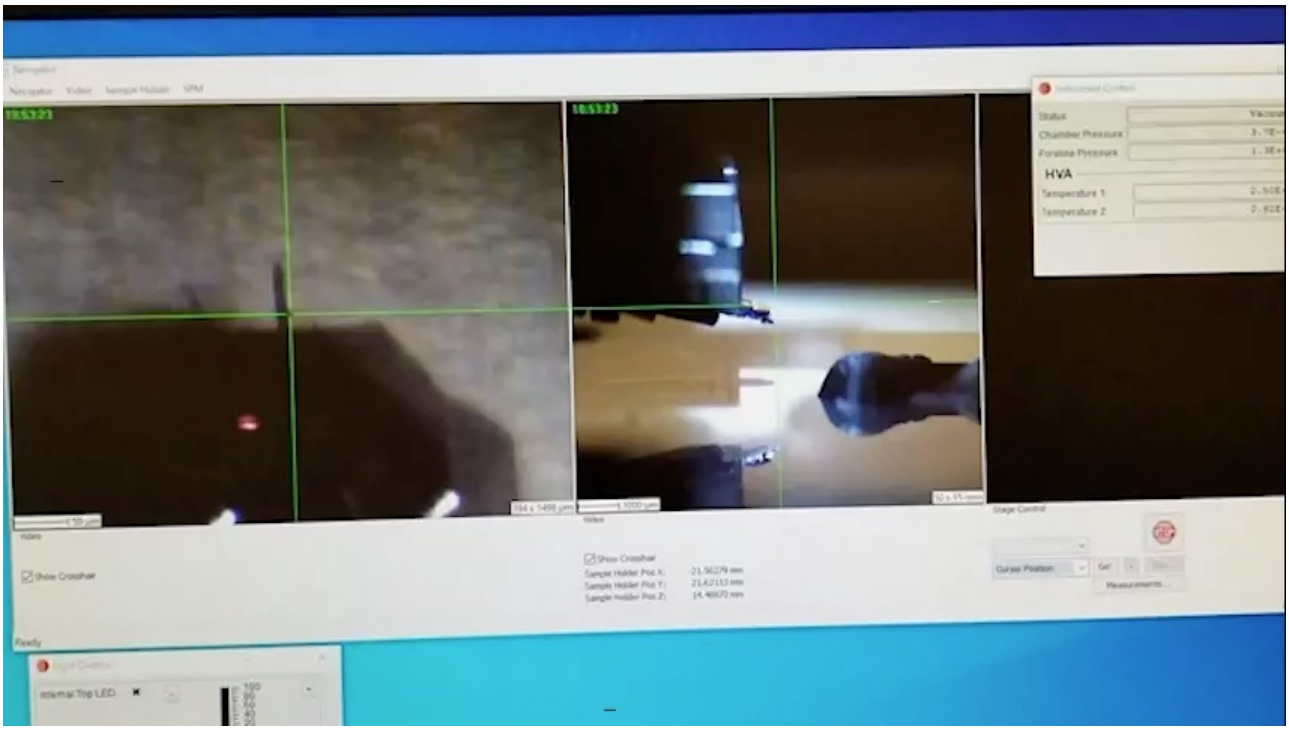
AFM / MFM Imaging 1

Place a sample on the stage :

Taken by Dr Kelvin Elphick

AFM / MFM Imaging 2

Approach the tip to the sample and execute AFM / MFM imaging :



Taken by Dr Kelvin Elphick

AFM / MFM Analysis

From the MFM image obtained, domain structures need to be sketched (see the slide 5 as an example.

By comparing with the magnetisation curve obtained by VSM, a magnetisation reversal process needs to be discussed.

A modelling software can be used to simulate the magnetisation reversal, such as OOMMF (Object Oriented MicroMagnetic Framework, see the online tutorial at https://www.spintalks.org/tutorials and the software details at https://math.nist.gov/oommf/)

In the reversal process, magnetic anisotropy needs to be considered and discussed.