

# Scanning Probe Microscopy 2

## derived methods

### Nanomaterials characterization 1

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

# Some of the next methods (derived from AFM and STM)

**STM**

- STS  $\equiv$  Scanning Tunneling Spectroscopy
  - Determination of materials energy structure
- PSTM  $\equiv$  Photon Scanning Tunneling Microscopy

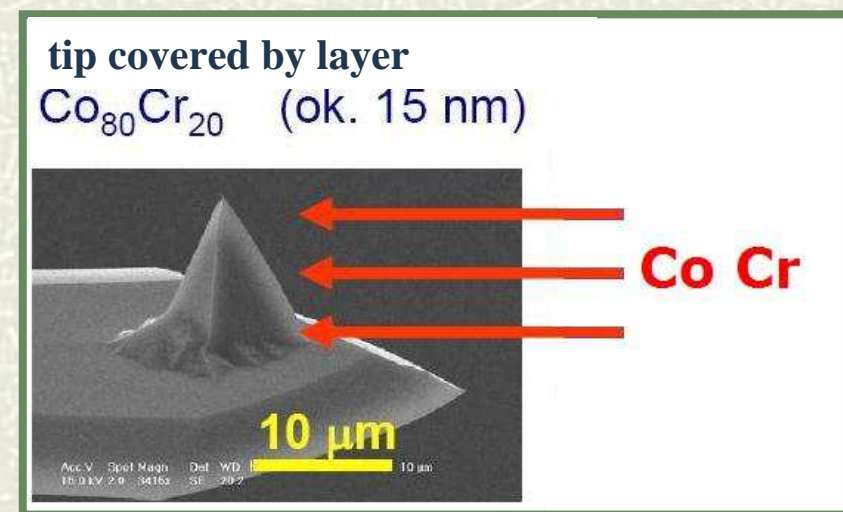
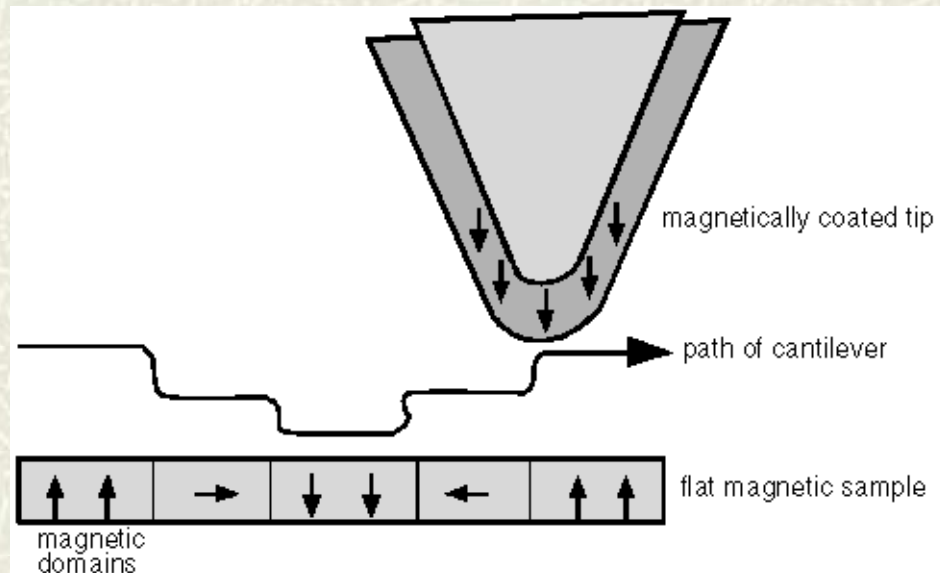
**AFM**

- MFM  $\equiv$  Magnetic Force Microscopy
  - Used force = magnetic force
- EFM  $\equiv$  Electric Force Microscopy
  - Used force = electrostatic force
- LFM  $\equiv$  Lateral Force Microscopy
  - Lateral force = force created by traction of tip on specimen surface
- SNOM  $\equiv$  Scanning Near-Field Optical Microscopy
  - Using of evanescent waves field

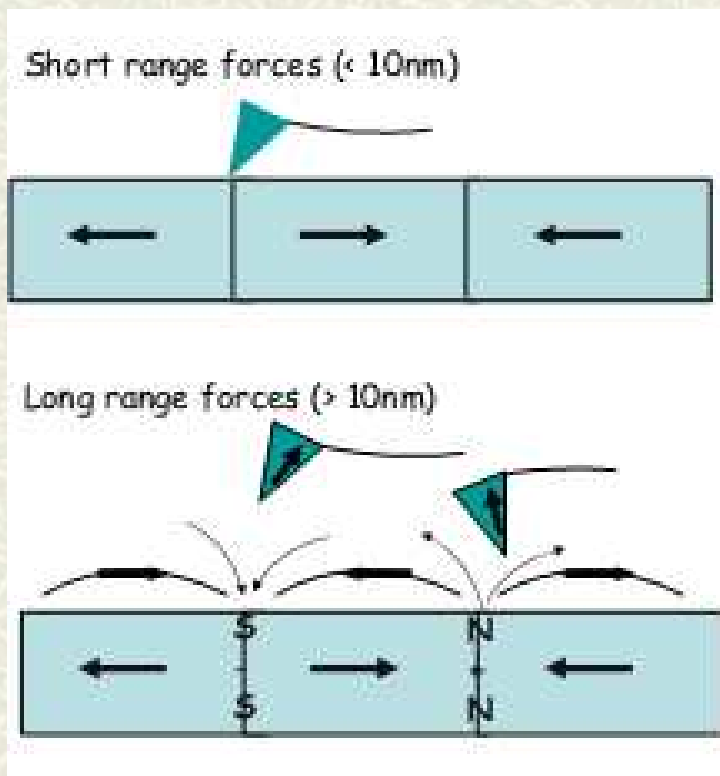


# MFM $\equiv$ Magnetic Force Microscopy

- Monitoring of magnetic force used
- Tip coated with thin magnetic layer, non-contact mode
- Magnetic domain mapping, surface topography



# MFM = AFM with magnetized tip



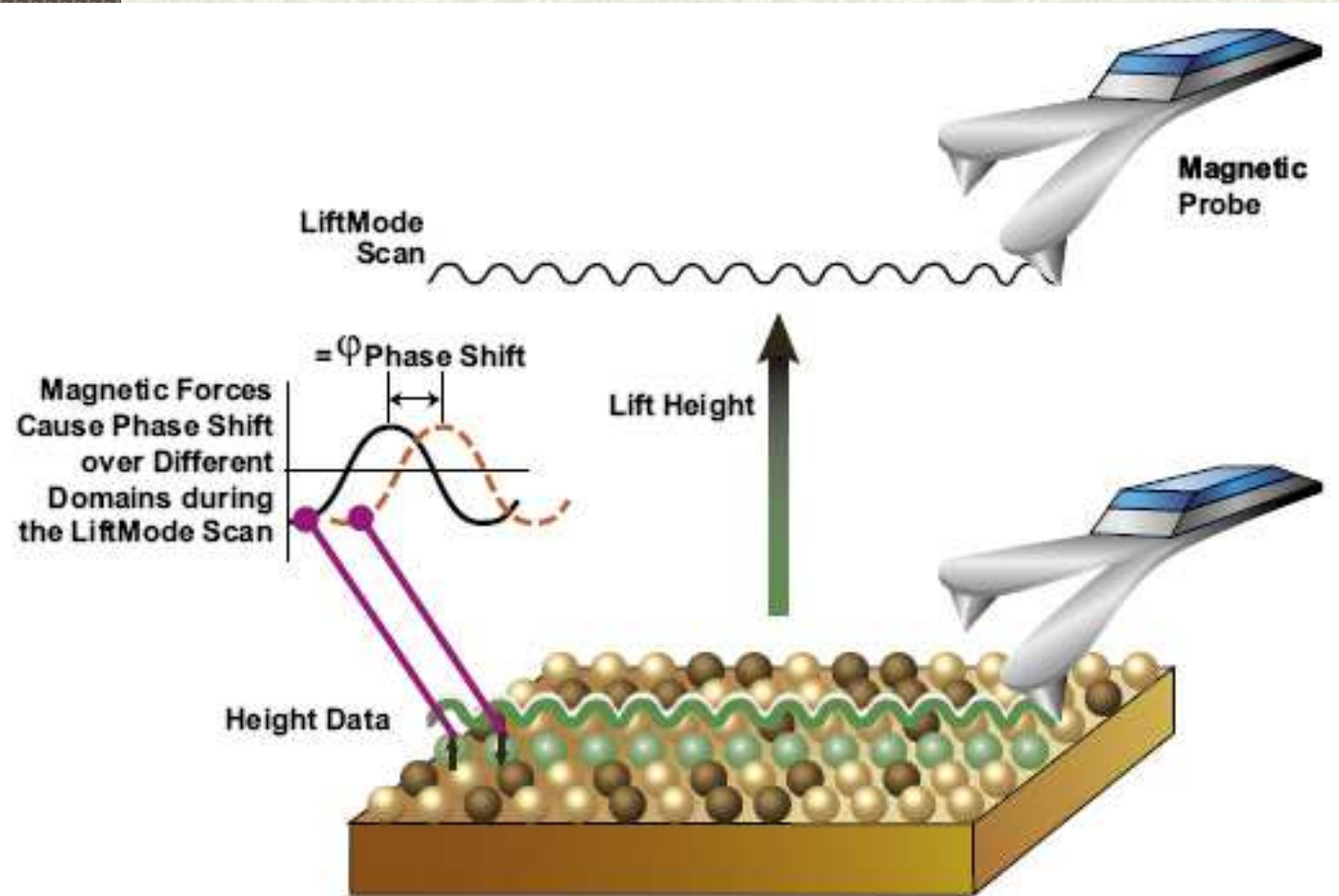
## Contact mode (AFM)

- sharp tip interacts with surfaces forces
- maps surface topography

## Noncontacts mode

- magnetic tip interacts with sample's stray magnetic field
- maps magnetic forces

# MFM – scheme of the method





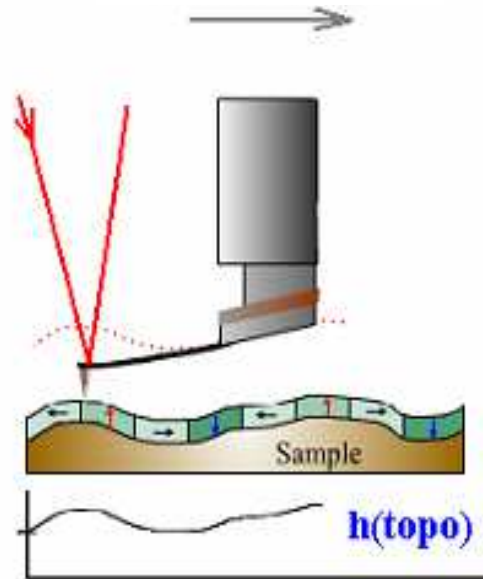
# MFM – working modes

**1.** Topographic profile – semicontact („tapping”) mode – tip moving on the specimen surface ( $\equiv$  AFM)

**2.** magnetic contrast (along topographic profile), non-contact scanning

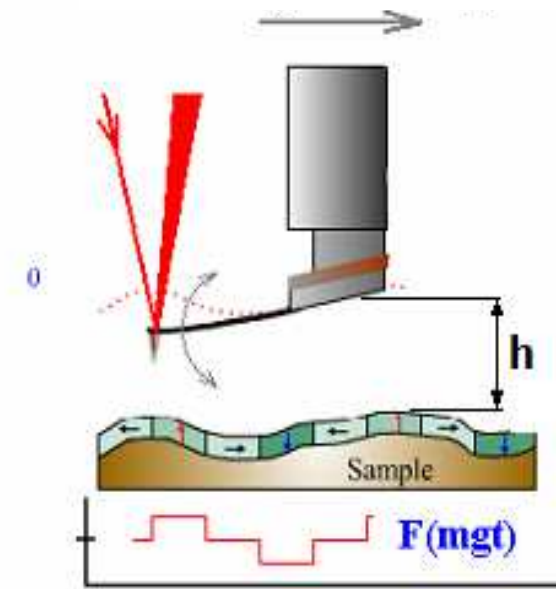
## MICROSCOPY OF MAGNETIC POWERS

1. topography



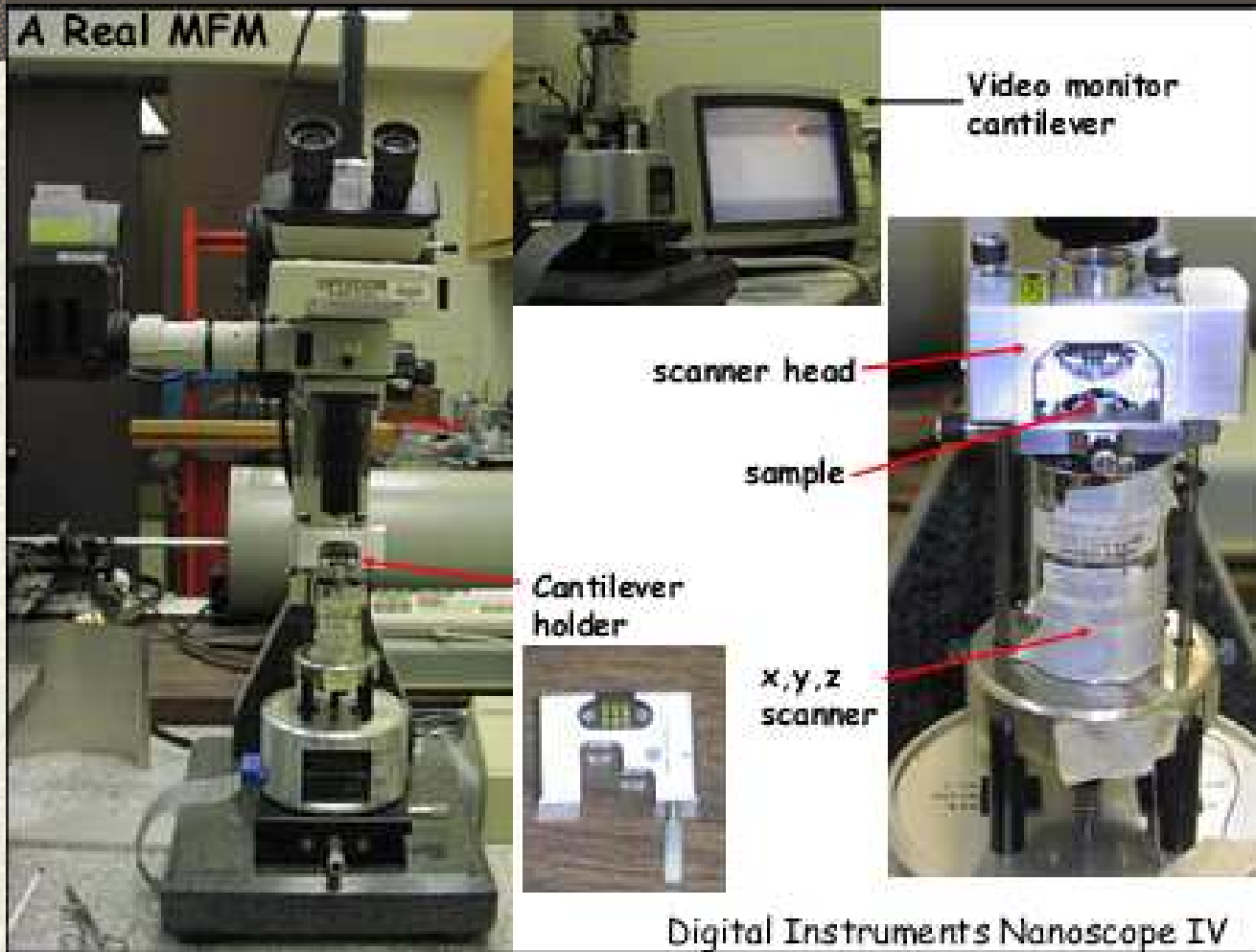
van der Waals' powers  
(semi-contact scanning)

2. magnetic powers



non-contact scanning

# MFM - configuration

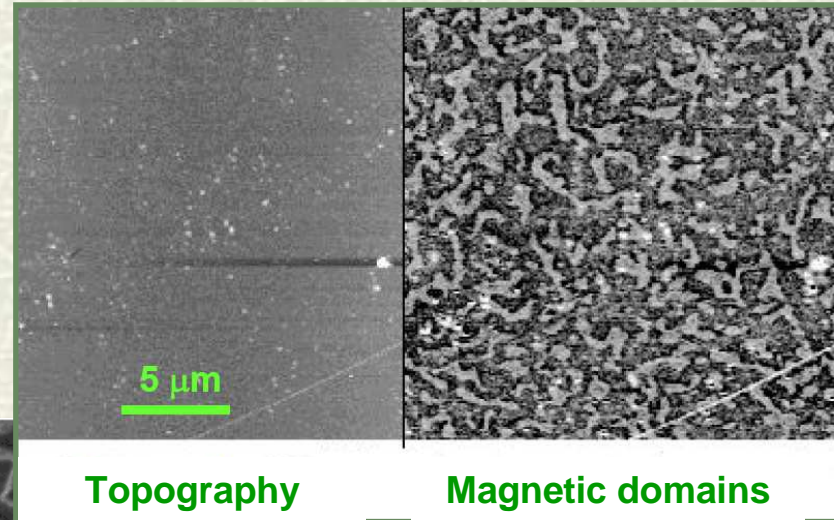
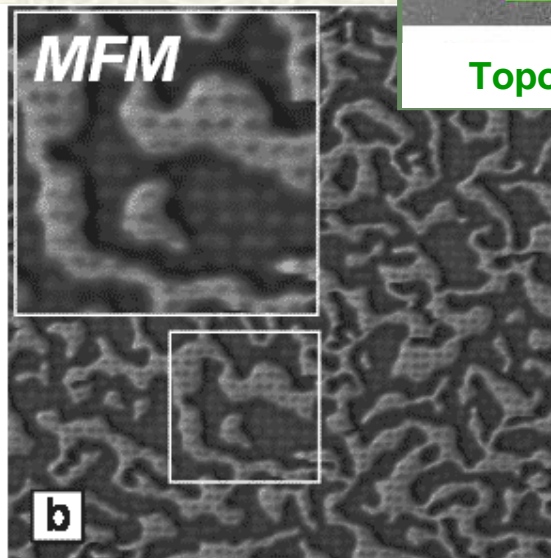
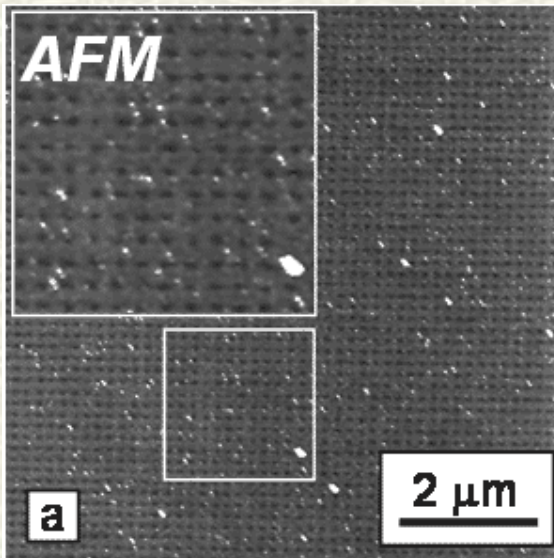




# MFM - using

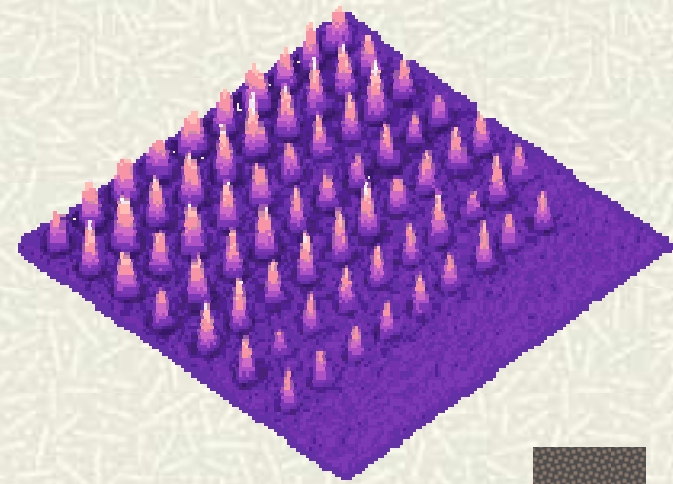
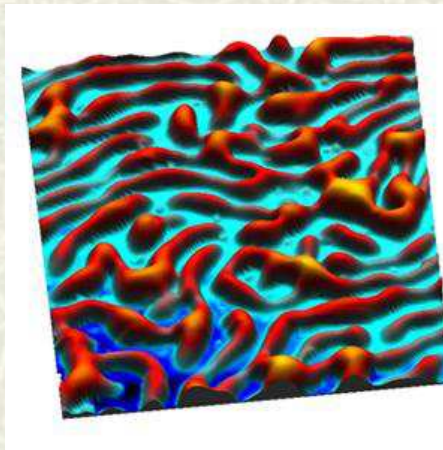
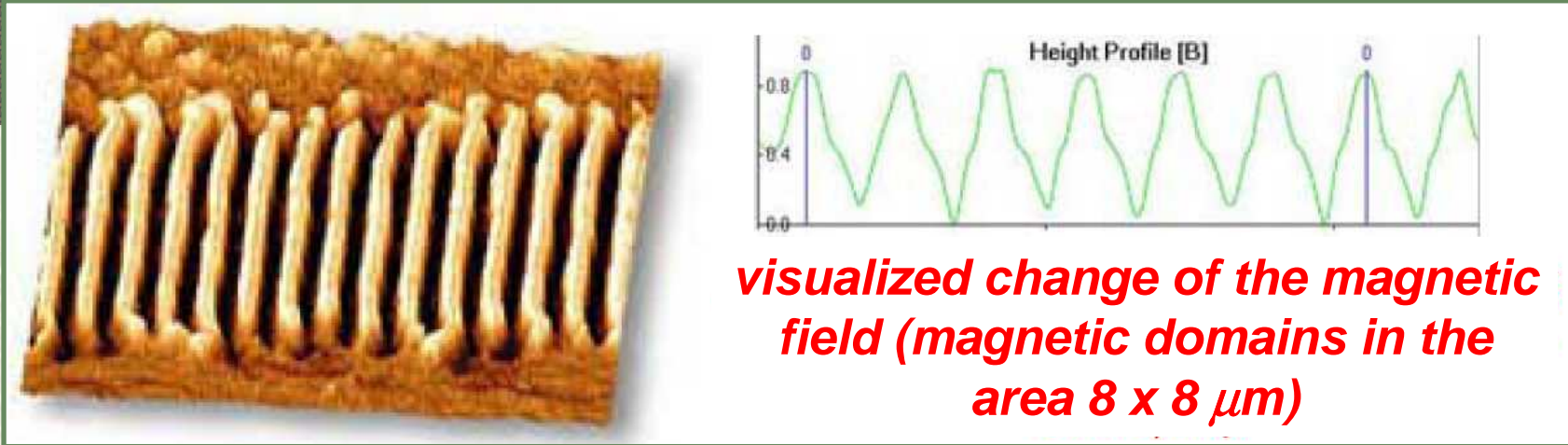
## Mapping of domains in magnetic materials

Ultrathin layer of Co  
( $d=1\text{nm}$ )

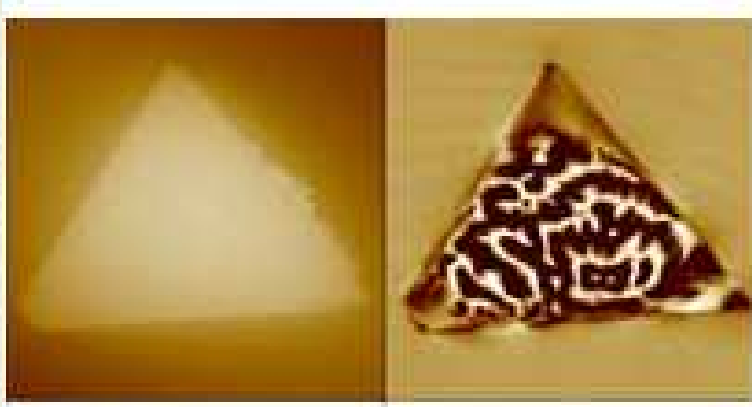




# MFM - using

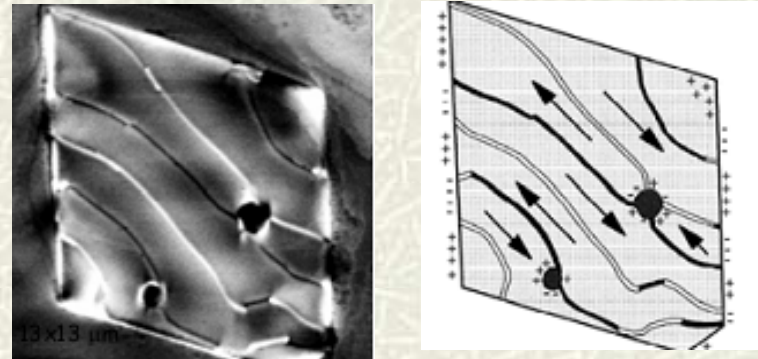


# MFM - using



AFM (left) and MFM (right) image of Glass ceramic Magnetite

## Qualitative interpretation of MFM images



MFM image of magnetite grain with direction of magnetization nearly parallel to surface of grain as indicated by similar contrast between domains



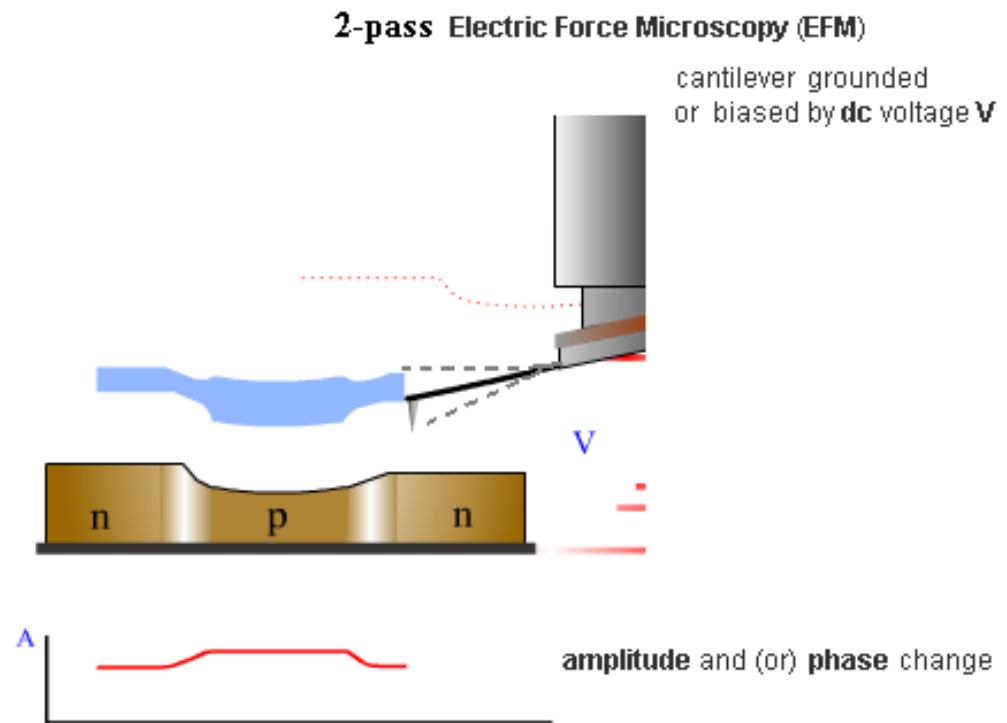
# EFM $\equiv$ Electric Force Microscopy

- electrostatic force used
- magnetic force microscopy analogy
- differences in topography, permittivity or charge density are recorded in mapping



# EFM – principle of method

- tip and surface connected to voltage, but without touch
- charge change on the specimen surface → cantilever bending in dependence on charge quantity
- deflection measurement – default detection system with laser beam  
(alternative way – oscillating of cantilever, resonance frequency measurement)





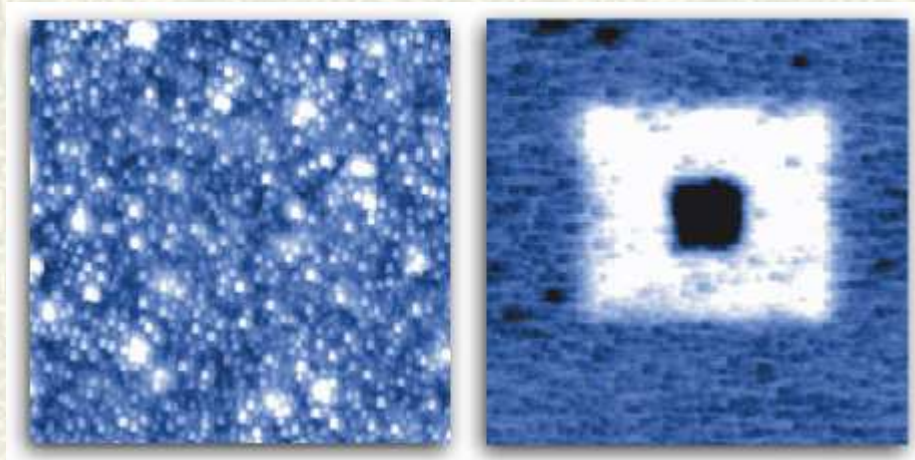
# EFM – using

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- # observation of surface electric properties
- # searching for integrated circuits defects
- # electrostatic field mapping of electronic circuits during switch-on and switch-off („voltage microprobe“ for active microchips testing)
- # particle distribution measurement on the surface of composite

# EFM – using

**Ferroelectric material with implanted surface charge (+2,5 V). Area 5 x 5  $\mu\text{m}$ .**



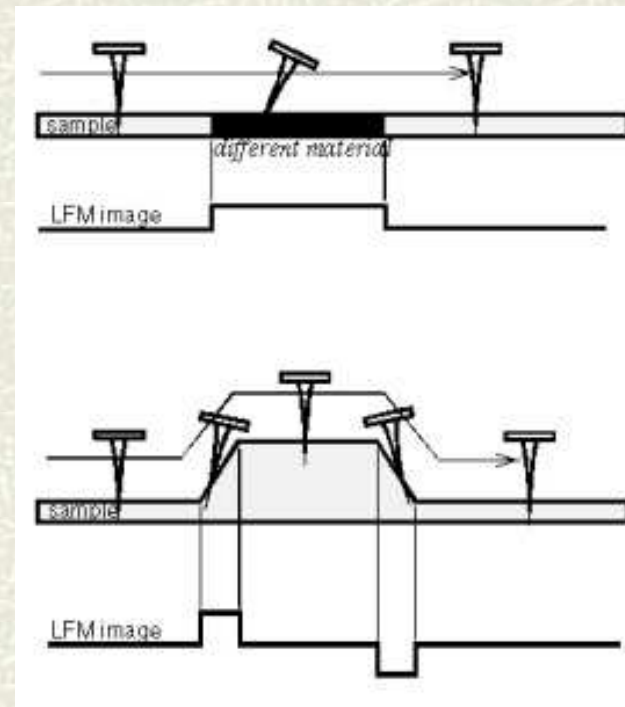
**Topographic  
contrast**

**EFM image of  
charged surface**

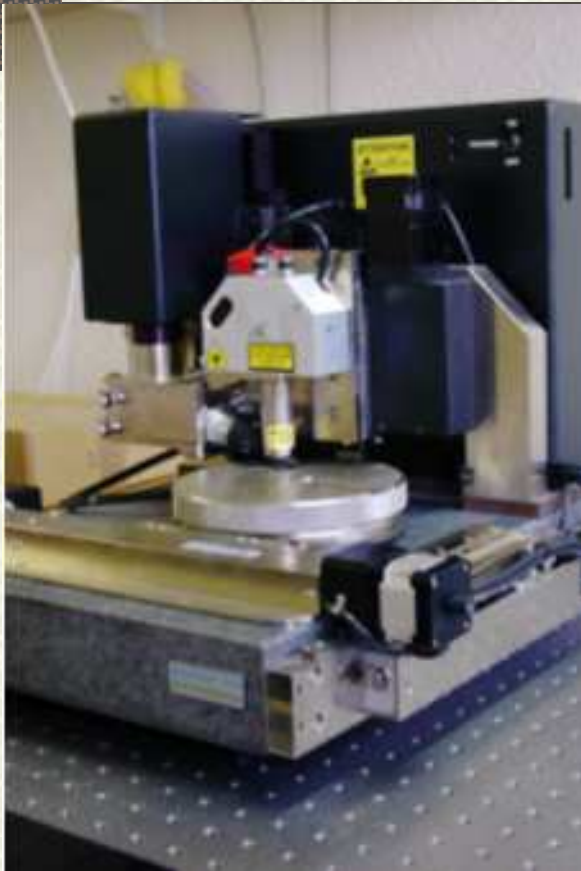


# LFM $\equiv$ Lateral Force Microscopy

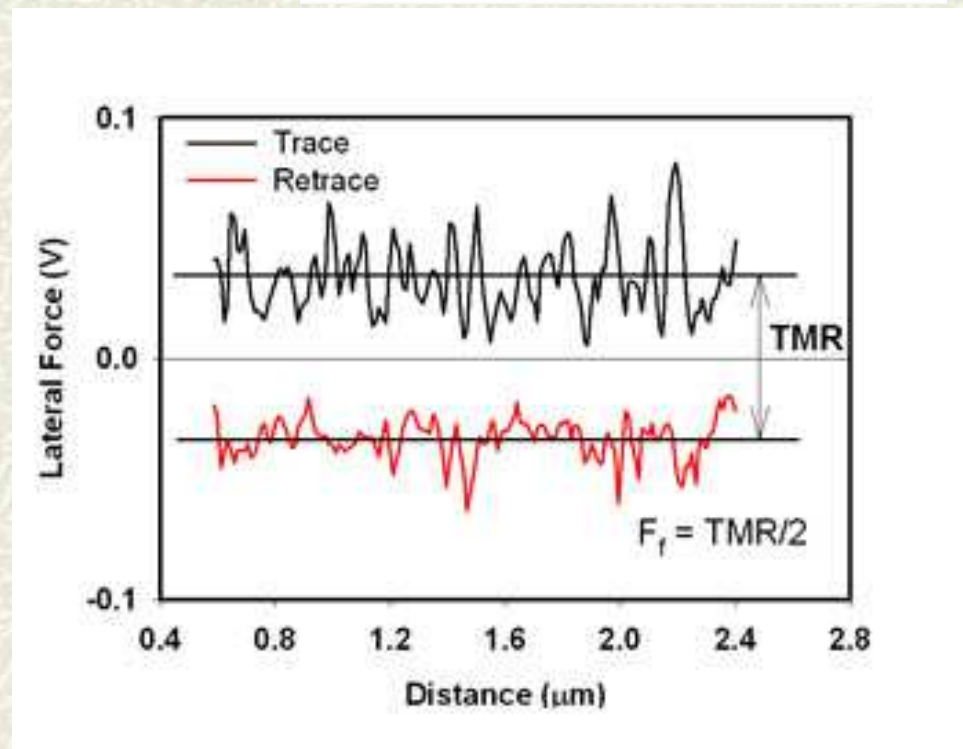
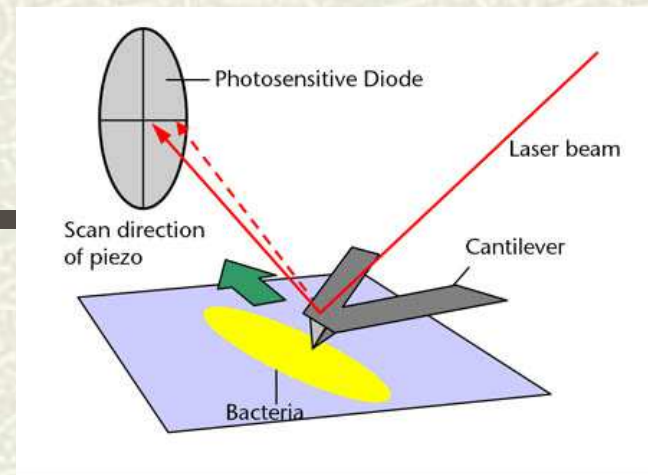
- forces created by traction of the tip on the specimen surface are measured
- console torsion is recorded
- usually used with AFM simultaneously



# LFM - scheme



Nanoscope DI 3100  
(AFM, LFM, MFM)





# LFM - using

