AFM 자율사용자 교육

UNIST

UCRF Self-user System

1. UCRF 회원가입 및 출입신청
   - UCRF homepage : http://ucrf-eng.unist.ac.kr/main/main.php
   - 출입신청 담당자 (유혜정 B122, 4038) 방문 → 신청서 작성 → 담당교수 서명 → 담당자에게 제출

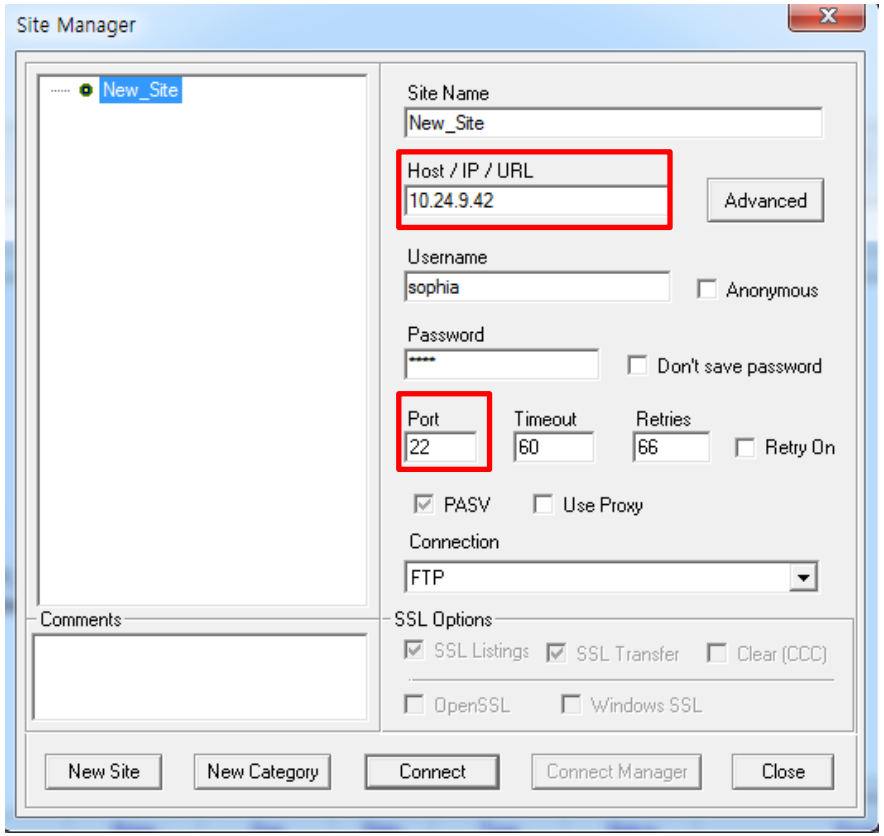
2. Log in system (True Café)
   - Self-user Test를 통과한 사람에 한하여 부여하며 1개의 아이디로 모든 분석장비 Login 가능, 단 동시 로그인 불가
   - 자동으로 Login or Logout 시간을 저장

3. Data Upload & Download System (Core FTP)
   - 분석 PC 보호차원에서 모든 Self-user 및 의뢰자 사용 (강제-usb 사용 X)
   - Core FTP 설치후 IP, ID, PW, Port 정보 입력 후 사용
   - USB없이 본인의 PC에서 결과를 바로 다운 받아 볼수 있음.
   - 용량초과시 자동삭제 기능 → 반드시 본인 Data 관리는 철저히 할 것.

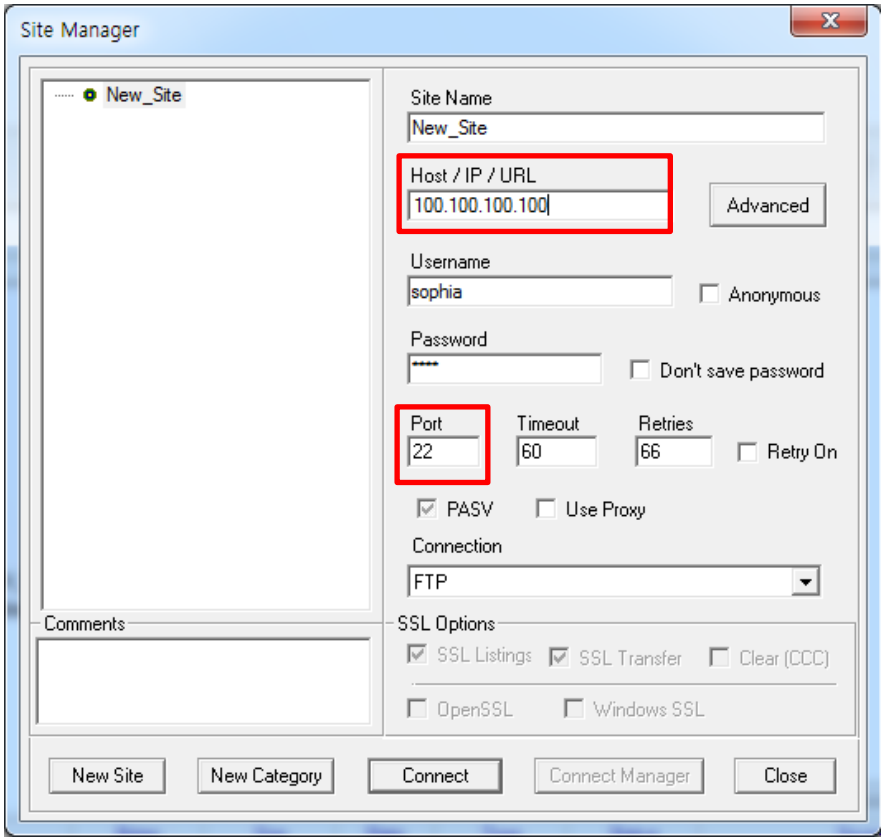
4. Logbook
   - 법적 감사자료
   - 새벽에 측정이 끝나는 Self-user를 위한 메모 가능

Log in System

외부 PC 접속시

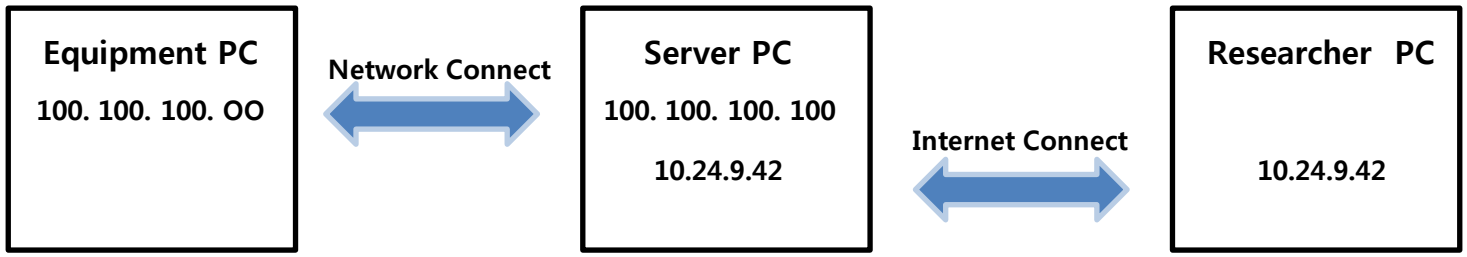


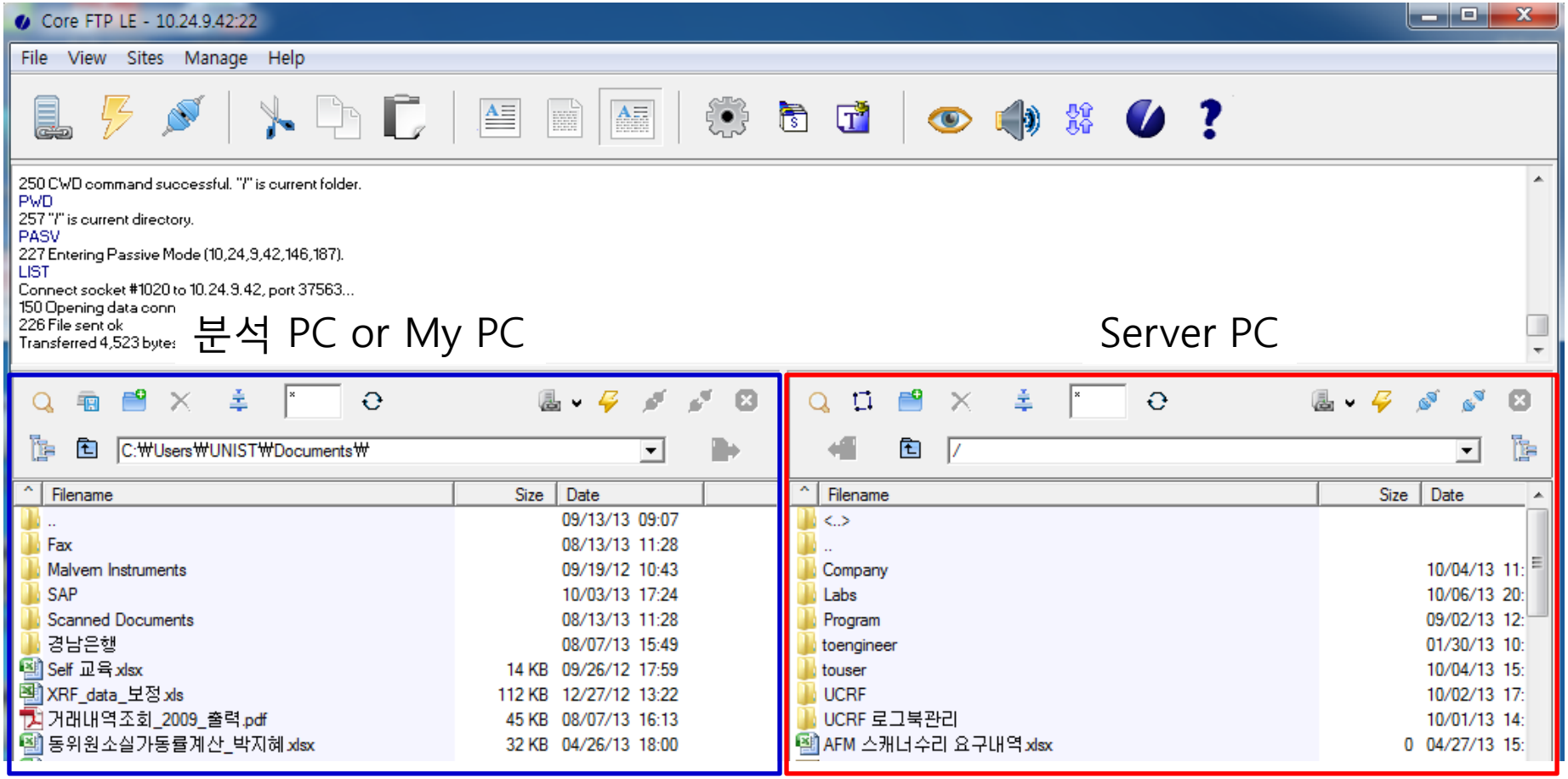
UCRF 내부 PC 접속시



Common ID : sophia
Common PW : 0687

Log in System

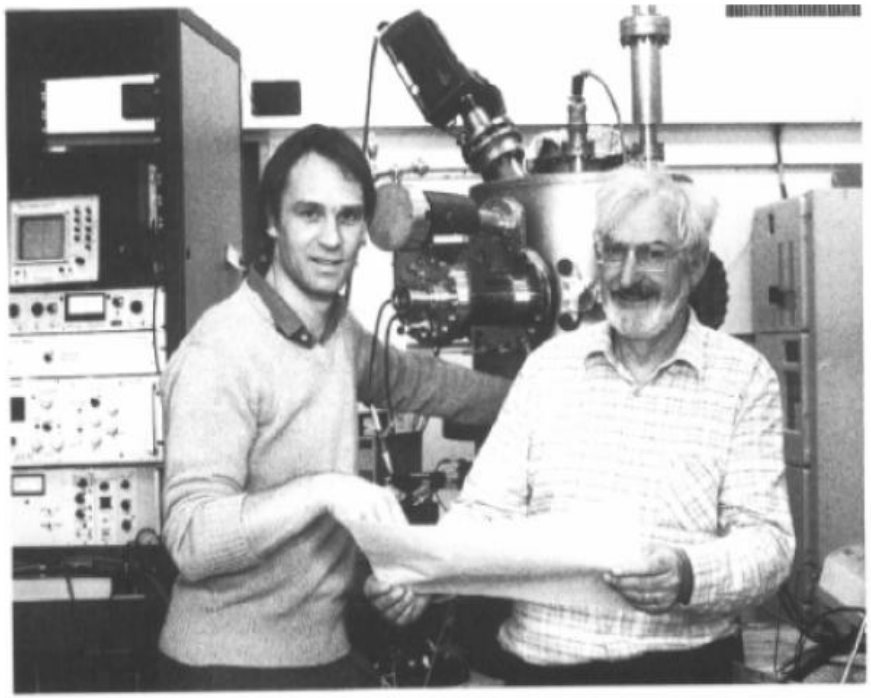




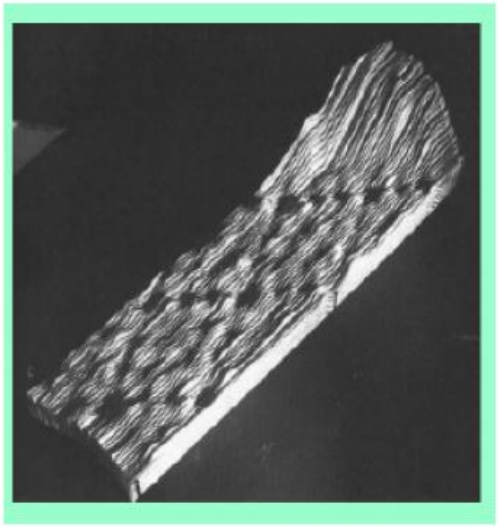
SPM의 역사

- 주사 탐침 현미경 (SPM) = STM + AFM
  - STM (Scanning Tunneling Microscope)
    - 1982 : Bining, Rohrer, Gerber, and Weibel at IBM, Zurich 개발
    - 1986 : Received Nobel Prize
  - AFM (Atomic Force Microscope)
    - 1986 : Binning, Quate, and Gerber, IBM and Standford 개발
    - 1989 : 처음으로 상품화
      Tapping Mode™ AFM 개발
    - 1994 : Fluid Tapping ™ Mode 개발
    - 2001 : Fast Scan 개발
    - 2003 : TR-Mode™ 개발
    - 2006 : Harmonic Image 개발

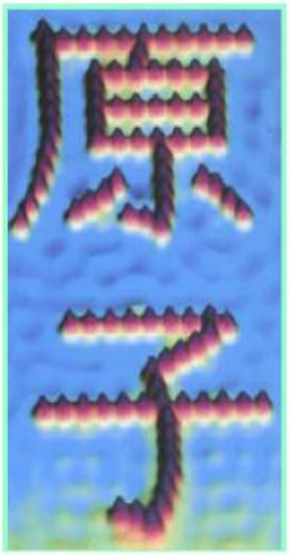
SPM의 역사



Gerd Binnig (left) and Heinrich Rohrer (right) who were awarded the Nobel Prize for their invention of the scanning tunneling microscope.



Si 7x7 surface reconstruction



China word "atom"

SPM 의 특징

	광학현미경	FIELD SEM	Conforcal	SPM(AFM)
측 정 환 경	대기중	진공	대기중	대기중, 용액내, 진공
시 료	액체	고체	액체, 고체	액체, 고체
x, y 축 분해능 z 축 분해능	1.0㎛, 1.0㎛ 0	5nm, 5nm 0	170nm 500nm	0.1nm 0.01nm
배 율	1~2x10^{3}배	10 ~ 10^{6}배	10 ~ 10^{4}배	25 ~10^{8}배
시료 전처리	간단한 전처리	Freeze drying Au-coating,복잡	간단한 전처리	거의불필요
시 료 손 상	없음	빔에 의한 손상	빔에 의한 손상	없음
시료준비시간	빠름	장시간소요	다소 소요	빠름
유지 관리비	거의 없음	매우 많음	다소 소요	거의 없음
시료전처리장비	거의 없음	매우 많음	다소 소요	거의 없음
분 석 능 력	정적분석 ex situ 분석 정성분석불가	<==	<==	동적분석가 in situ 분석가 정성분석가

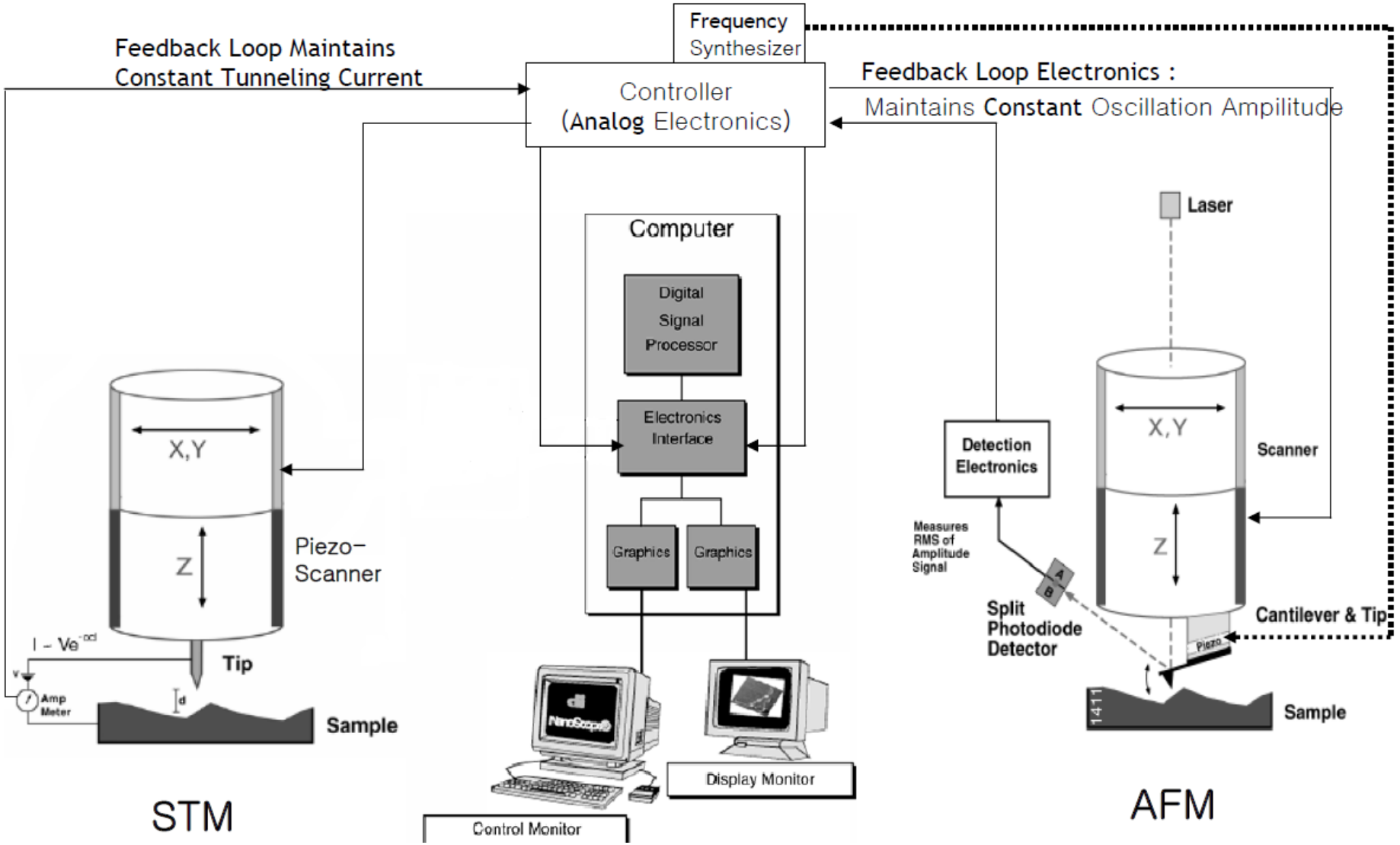
SPM 특징

- 고해상도의 3차원 측정
  - sub nm (Lateral), sub Å (Vertical)
- 액중 측정 가능
- 환경 실험의 가능
- 물리적 특성 측정 가능(MFM,EFM,SCM,SSRM,TUNA….)
- 컴퓨터와 같이 기능 확장 및 Upgrade 가능(Instrumentation)
- Fast, Simple Sample Preparation

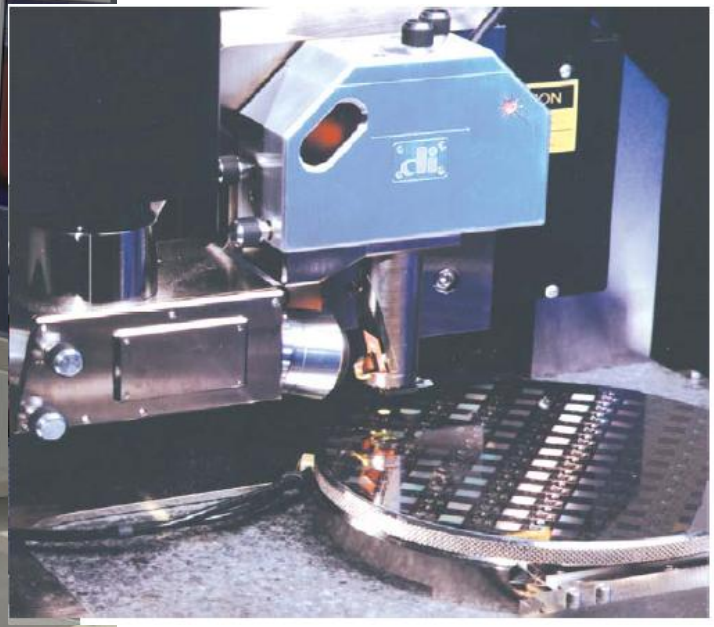
Primary Application

- Electronic Materials/Semiconductor
- Polymers
- Life Sciences
- Data Storage
- Opto/Telecom
- Optics
- Nanotechnology
- MEMS
- Electrochemistry
- Materials/Surface Science

기본원리


Frequency
Synthesizer
Feedback Loop Maintains
Constant Tunneling Current
Controller
(Analog Electronics)
Feedback Loop Electronics :
Maintains Constant Oscillation Ampilitude
Computer
Digital
Signal
Processor
Electronics
Interface
Graphics
Graphics
Laser
X,Y
Z
Piezo–
Scanner
Detection
Electronics
Measures
RMS of
Amplitude
Signal
A
B
Split
Photodiode
Detector
Scanner
Cantilever & Tip
Piezo
Tip
Amp
Meter
Sample
Sample
Display Monitor
Control Monitor
STM
AFM

Large Stage SPM(Dimension)



150mm(Max:up to 200mm)

Sample Stage size:

샘플 크기/하중에 스캐너가 자유롭다.

샘플은 스캐너 아래에 고정하고 측정 하는 방식!

Small Stage SPM(Mulrimode)

15mm(Or : up to 50mm)

Sample Stage size:

Small Stage SPM의 경우
최대 50mm 이상의 샘플을
올려 놓으면 과부하가 걸려
정밀한 측정이 어려워 진다.

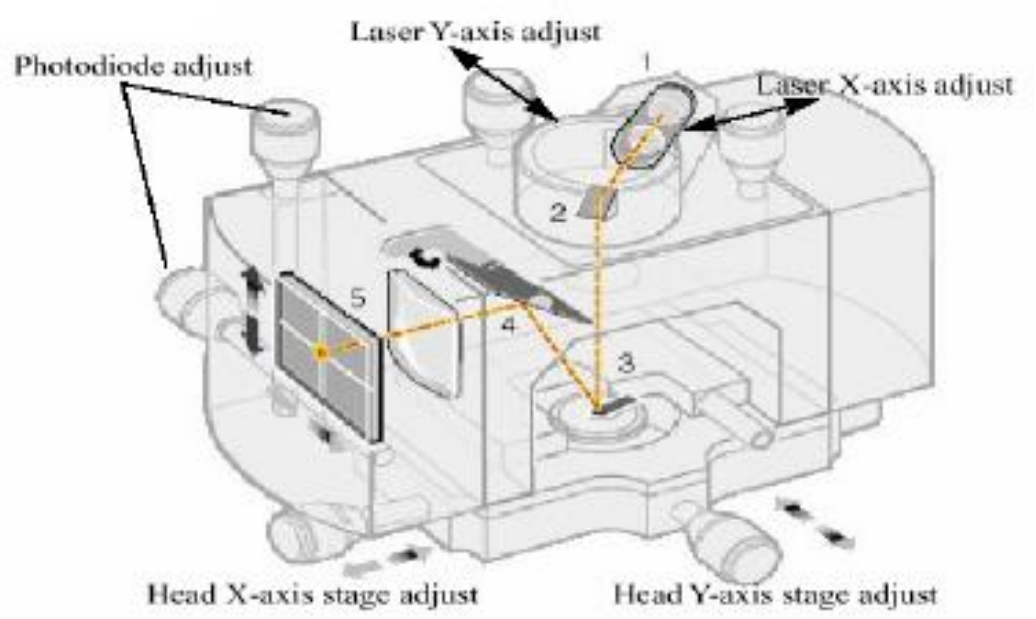
샘플을 스캐너 위에 올려 놓고
측정 하는 방식!

Scanning the Tip or Sample?

- General rule: keep the scanning mass as small as possible
  - = faster response time = better tip/sample tracking
  - = lower inertia = more linear scan motions

- Configurations:
  - Scanning the sample in XYZ
  - Scanning the tip in XYZ
  - Scanning both the tip and sample
  - tip XYZ and sample XYZ
  - tip Z, sample XY

Scanning the Sample



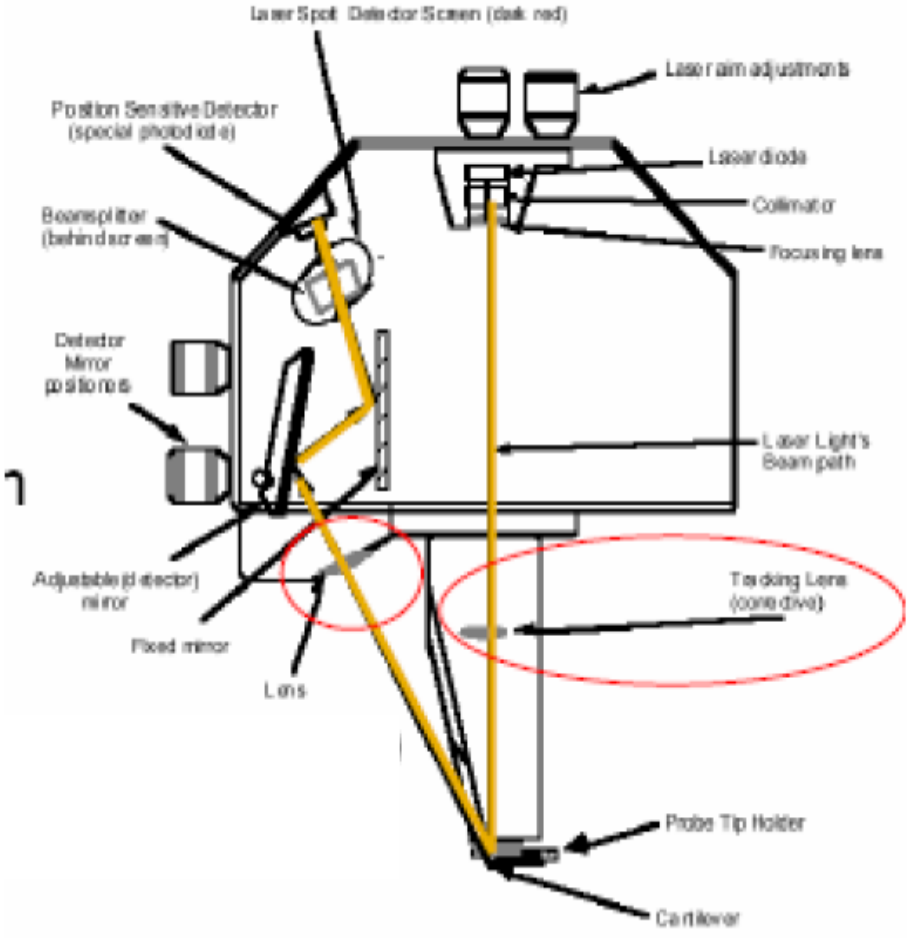
- Laser is always perfectly aligned on cantilever = highest resolution
- Compact design, where the 'mechanical path' can be very small = most stable setups
- Only good for relatively small samples

Scanning the Tip

- Good for large samples
- Typically results in larger mechanical path = less stability
- Requires mechanism to keep the laser focused & XY aligned on the cantilever at all times, this makes the scanner assembly more complex

Configurations:

1. Move the PD and laser with the tip
   - Heavy mass, hence slower
   - Example: “J” company
2. PD & laser fixed: Use a lens systemfor tracking
   - No added mass
   - Example: D3100, BiosocpeSZ (Trackscan patent)



SPM Scanner 원리

일반적인 압전소자는 1 볼트당 1 nm 씩 늘어납니다. 따라서 큰 움직임을 얻기 위하여 그림과 같이 수백장의 압전소자를 겹쳐 놓습니다.

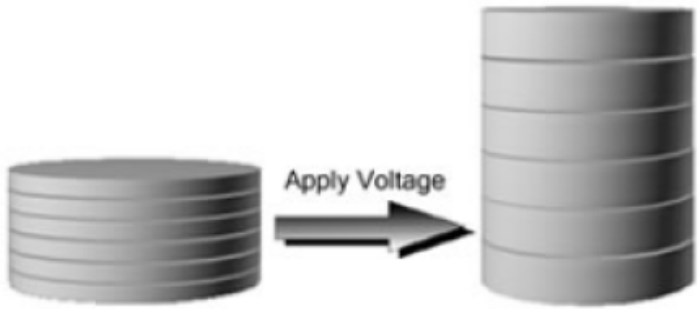


그림 : 이 압전 세라믹 판의 상부와 하부에 전압을 인가하면, 모든 판들이 늘어나게 된다. 늘어나는 양은 인가하는 전압과 압전 세라믹 판의 종류 및 디스크의 수량에 따라 상이합니다.

1000 장의 압전세라믹 판을 사용하는 경우 1 볼트당 1000 nm 씩 움직일 수가 있습니다. 따라서 이와 같은 여러 겹의 압전 세라믹 판에 100 볼트를 인가하면 0.1mm 를 움직일 수가 있습니다.

압전소자의 겹쳐진 수에 따라서 정밀도에 큰 상관 관계가 있습니다.

Closed loop & Open loop Scanner

- All SPMs use piezo's
- Piezo's are non-linear: hysteresis, creep
- Non-linearitities can be corrected for by:
- Software calibration: 'Open Loop'
- Works perfectly for imaging applications
- Limited for Zooming, Nanopositioning an nanoLithography
- Hardware sensors: 'Closed Loop'
- Works fine for all applications
- The sensor introduces some extra noise limits speed

Closed-loop technology

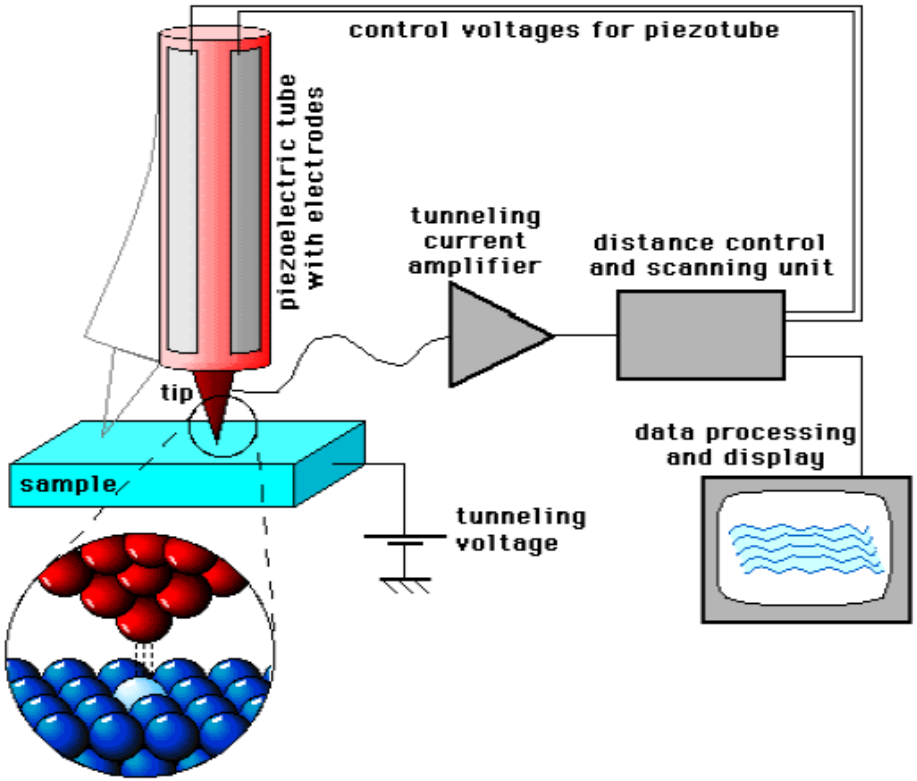
Closed-loop requires

- A position sensor to measure the actual position in a certain direction (can be capacitive, interferometric, optical, inductive,..)
- Feedback loop: to correct the actual position such that it corresponds to the desired position
- The important criteria are:
- Speed (sensor & feedback response time)
- Mass (increased mass, reduces speed)
- Resolution (sensor noise)

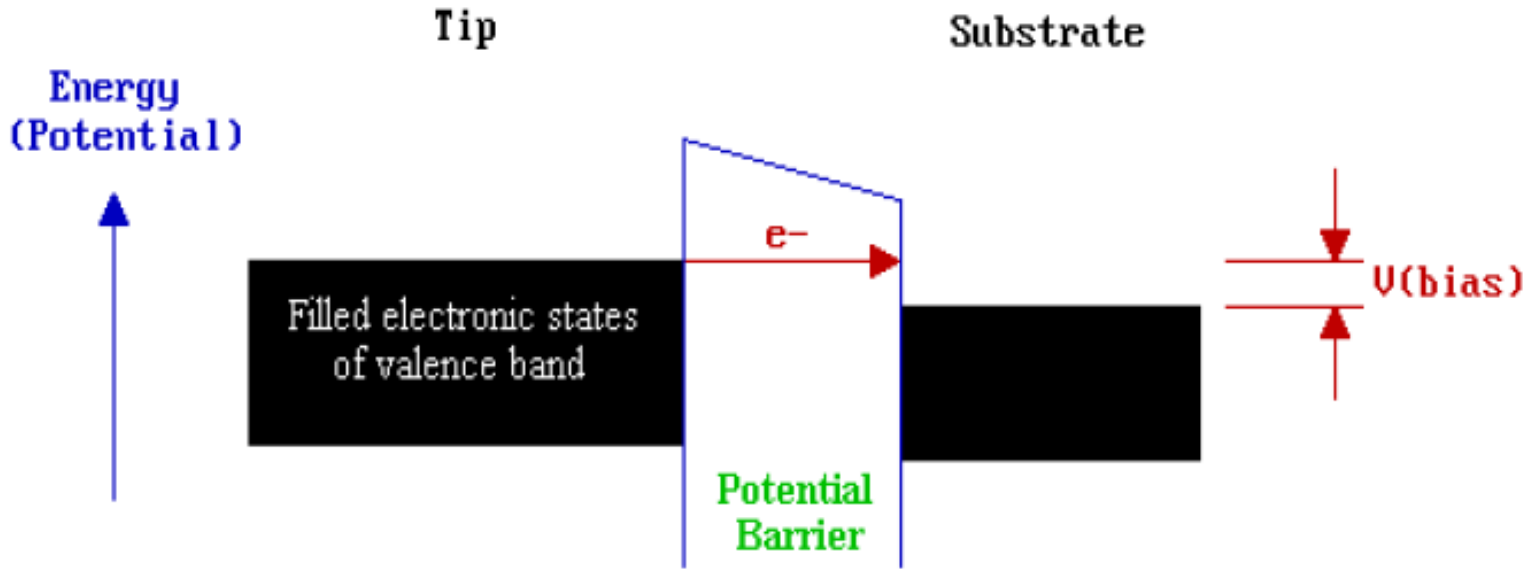
Closed loop is good, but not always the best!

STM

- 최초의 원자 현미경
- 가느다란 텅스텐 선을 전기 화학적으로 에칭 시키면 그 끝이 아주 뾰족하게 되어 맨 끝에는 원자 몇 개만이 존재하게 됨
- 원자 한 두개 크기의 간격(~0.5nm)으로 표면 접근 양자역학적 터널링 효과

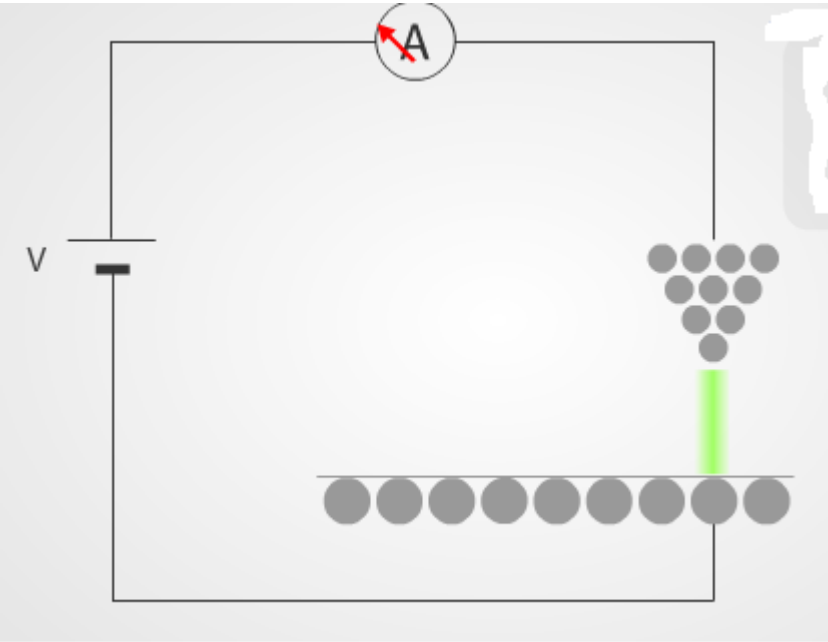


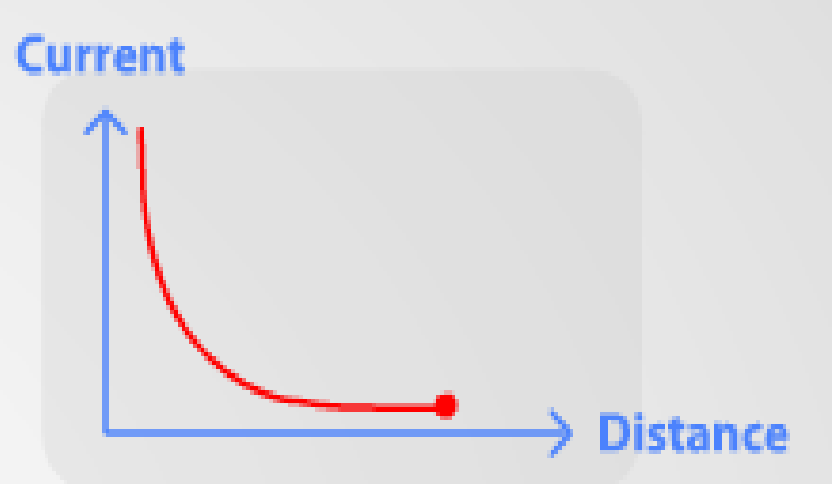
STM의 원리



- 원자 한, 두개 크기의 간격(**~0.5nm**)으로 가까이 접근
- 적당한 전압을 걸어주면 전자가 에너지 벽을 뚫고 지나가 전류가 흐름
- **STM**의 탐침과 시료 간격이 멀어지면 전자의 터널링 확률이 작아짐

STM의 원리

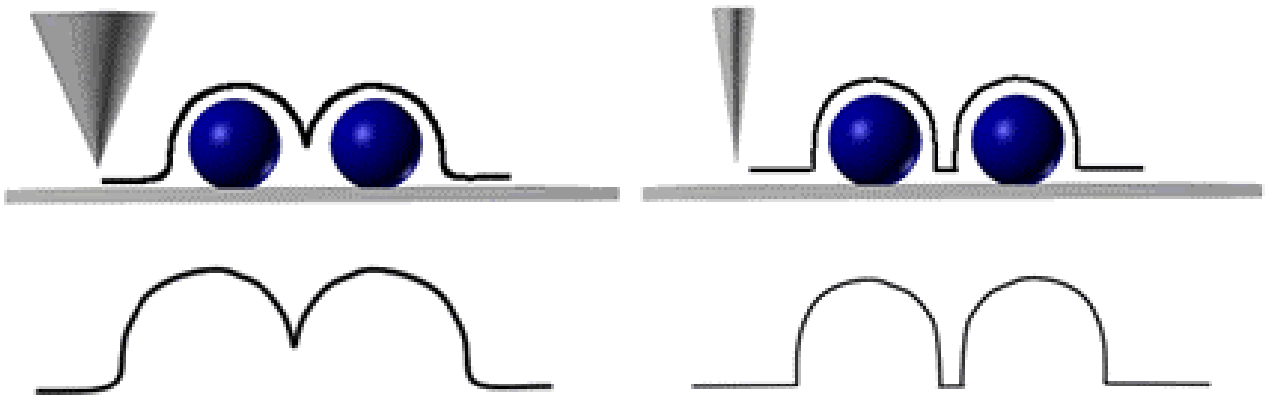




Tunneling current

Scanning Tunneling Microscopy (STM) probes metallic surfaces with a sharp metallic tip to obtain the tunneling current. As the tip and the sample are both conductive, a bias between the tip and the sample generates a tunneling current. The magnitude of the tunneling current is a function of the distance between the probe and the surface.

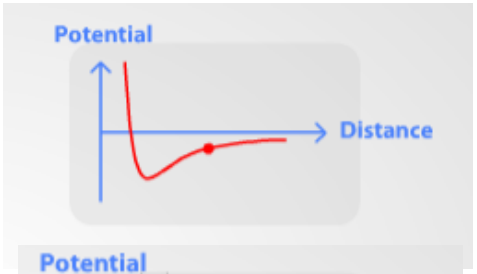
AFM 의 원리(분해능)

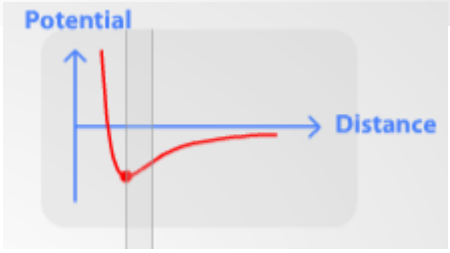


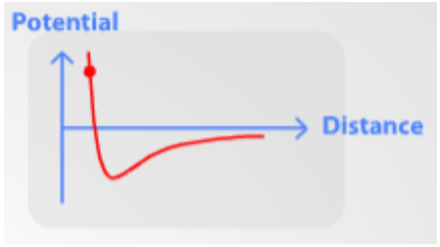
기존의 마이크로스코프는 한가지의 해상도,즉 평면에 대한 해상도만 있습니다. 반면, 원자현미경은 두가지 해상도,즉 평면에 대한 것과 시료 표면에 대하여 수직 방향의 것입니다.

평면 해상도(Plane Resolution): 이 평면 해상도는 스캔닝에 사용되는 프로브의 형상에 크게 좌우됩니다. 일반적으로, 프로브가 뾰족할수록 AFM 이미지의 해상도는 더 높아 집니다. 아래 그림에서 두개의 구를 뾰족한 프로브와 무딘 프로브를 사용하여 측정했을 때의 이상적인 스캔된 선들을 볼 수 있습니다.

AFM 의 원리(Surface Sensing)



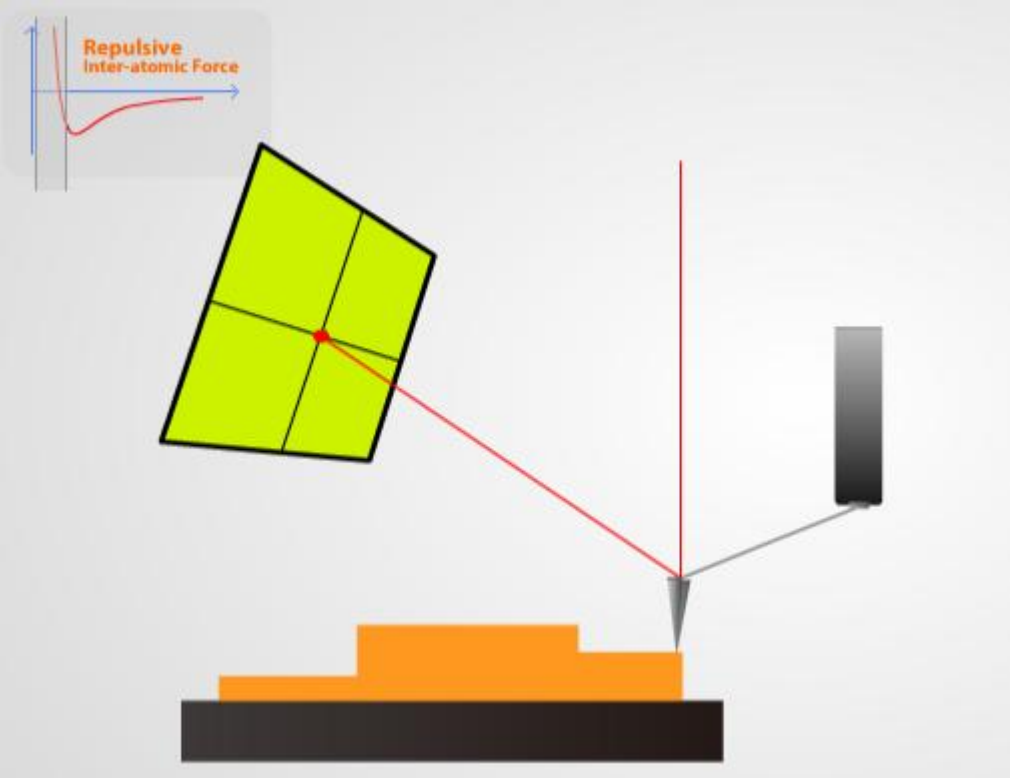


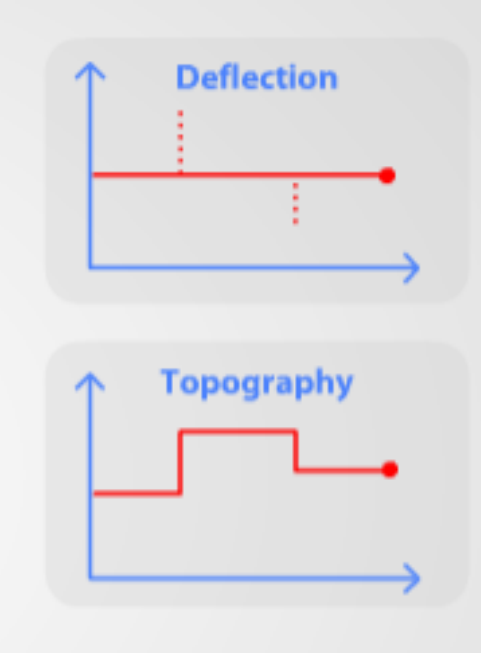


Surface Sensing

An AFM uses a cantilever with a very sharp tip to scan over a sample surface. As the tip approaches the surface, the close-range, attractive forces between the surface and the tip cause the cantilever to deflect towards the surface. However, as the cantilever is brought even closer to the surface, such that the tip is in contact with the surface, increasingly repulsive forces take over and cause the cantilever to deflect away from the surface.

Contact AFM

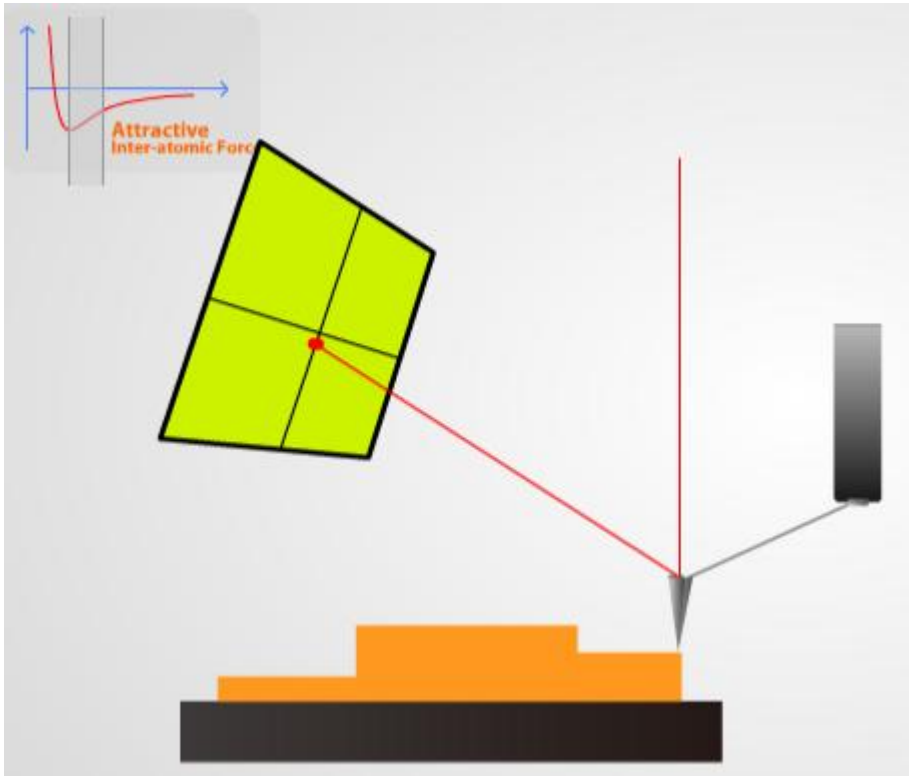


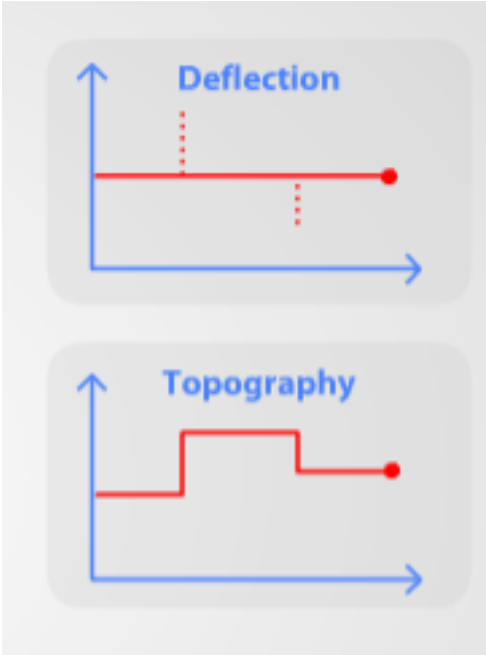


Contact AFM

In this method of surface imaging, the cantilever scans across a sample surface. Because the cantilever is in contact with surface, strong repulsive forces cause the cantilever to deflect as it passes over topographical features.

Contact AFM





Non-Contact AFM

In this technique, the cantilever oscillates just above the surface as it scans. A precise, high-speed feedback loop prevents the cantilever tip from crashing into the surface, keeping the tip sharp and leaving the surface untouched. As the tip approaches the sample surface, the oscillation amplitude of the cantilever decreases. By using the feedback loop to correct for these amplitude deviations, one can generate an image of the surface topography.

Charge

		Main body		Microscope
		ATR	ACC	
UNIST students	Client(70%)	21,000/hr	31,500/hr	42,000/hr
	Self-user(50%)	15,000/hr	22,500/hr	30,000/hr