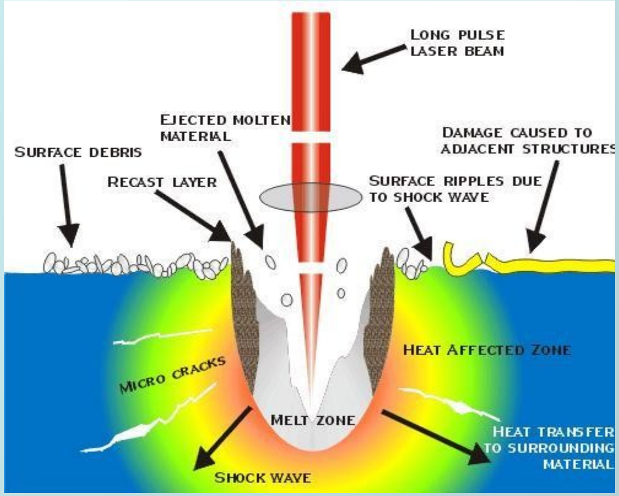
GENERATION OF CdTe NANOPARTICLES BY LASER ABLATION AND Cu Nanowires by SSNTD

Mitra Ghergherehchi

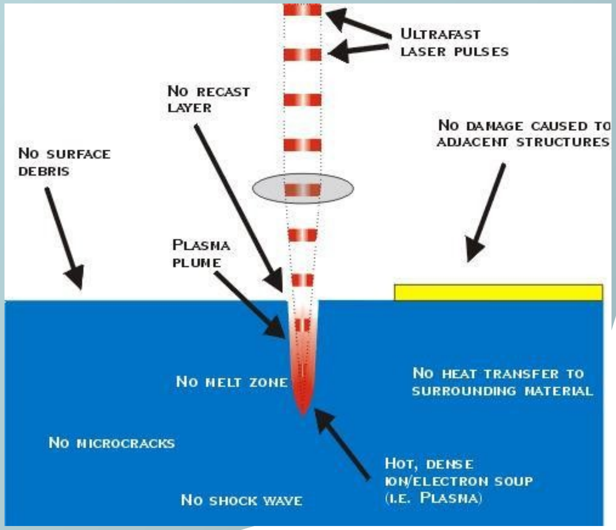
1. Chemical means
- Collidal route
- Electrochemical way

2. Physical means
- Evaporation-condensation method
- Arc discharge
- Laser mater interaction(laser ablation)

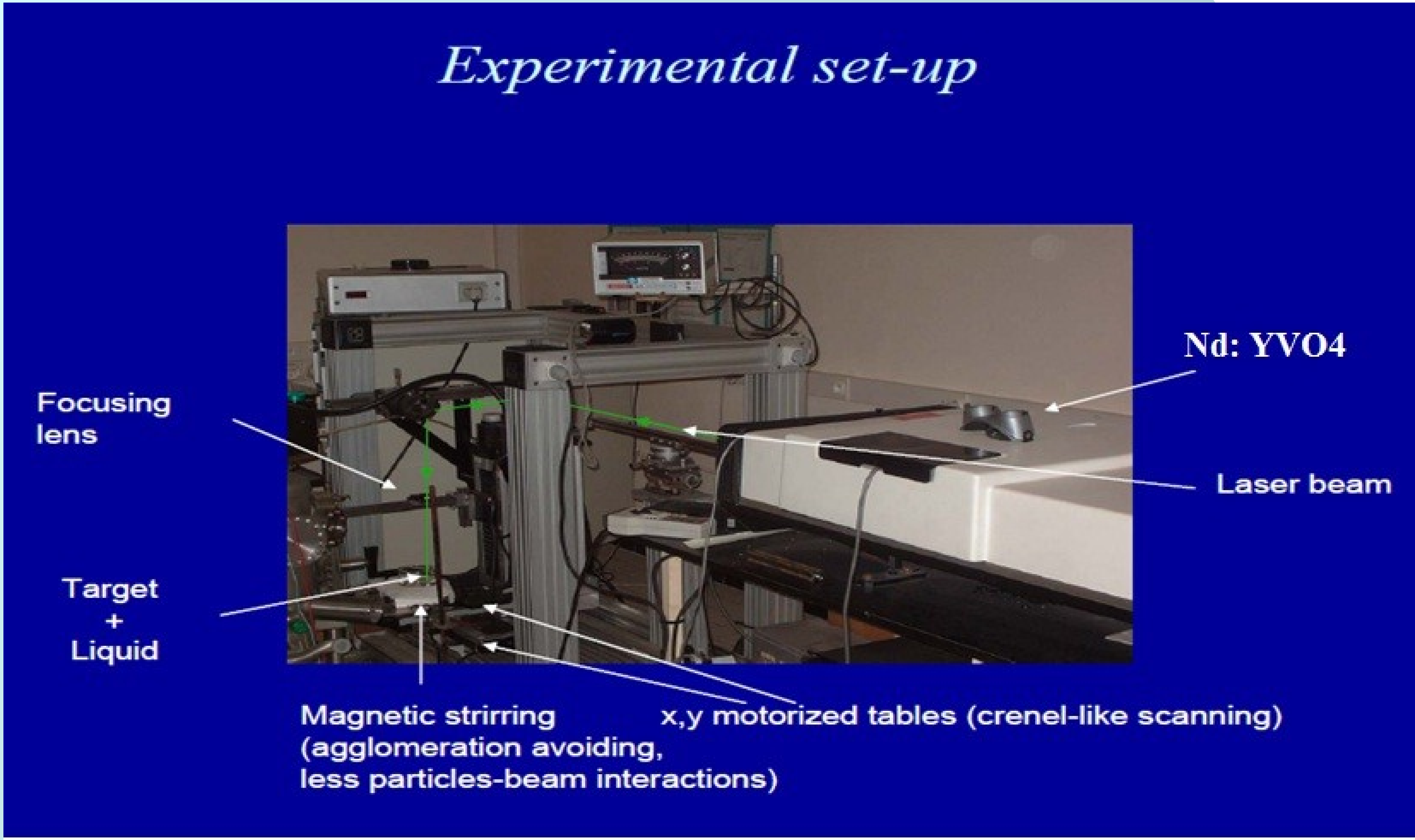
Laser ablation is the process of removing material from a solid (or occasionally liquid) surface by irradiating it with a laser beam.



Nanosecond regime and traditional Laser plasma ablation (long pulse laser)



Sub-Picosecond regime, ultra fast laser pulse, Ultra fast plasma laser ablation (UPLA)



A 20-TW laser system

The gain medium of the laser system is a Ti:sapphire crystal.

The minimum pulse duration of the laser system is 31 fs,

the maximum energy is 700 mJ.

Medical and IT Fusion Research Division, Korea Electrotechnology Research Institute

Semiconductor Materials

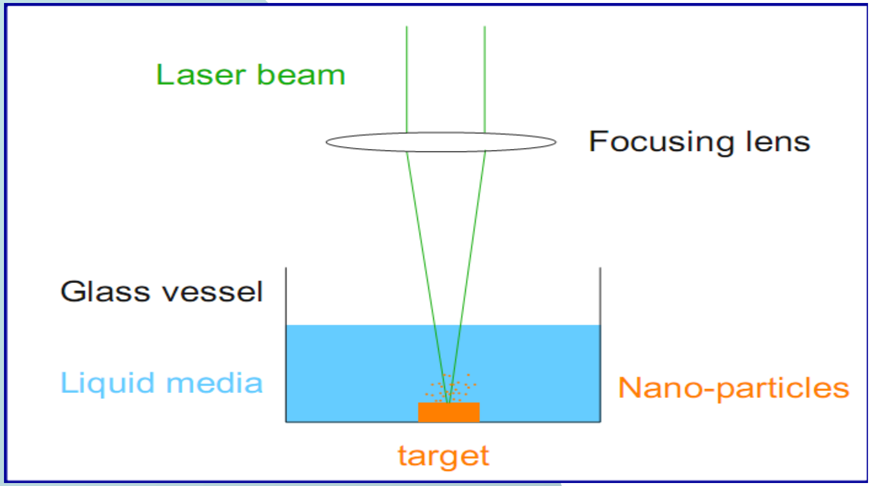
- large active volume
- high charge carrier motilities
- high atomic number
- be operable at room temperature without any cooling apparatus.
- Good energy resolution requires a relatively small bandgap,

Table 13.3 Properties of Semiconductor Materials

Material	Z	Density (g/cm^3)	Bandgap (eV)	Ionization Energy (eV per *e-h* pair)	Best Gamma-Ray Energy Resolution (FWHM)	Reference
Si (300 K)	14	2.33	1.12	3.61		65
(77 K)			1.16	3.76	400 eV at 60 keV	65
(77 K)					550 eV at 122 keV	65
Ge (77 K)	32	5.33	0.72	2.98	400 eV at 122 keV	65
					900 eV at 662 keV	65
					1300 eV at 1332 keV	57
CdTe (300 K)	48/52	6.06	1.52	4.43	1.7 keV at 60 keV	47, 58
					3.5 keV at 122 keV	58
HgI_2 (300 K)	80/53	6.4	2.13	4.3	3.2 keV at 122 keV	47, 72
					5.96 keV at 662 keV	72
$Cd_{0.8}Zn_{0.2}Te$ (300 K)	48/30/52	6	1.64	5.0	11.6 keV at 662 keV	47, 80

Application

- solar cells
- light-emitting diodes
- in biology



Pulsed laser ablation in a liquid media

The pulses were focused onto a piece of bulk semiconductor, which was held inside a quartz cell with 1 cm pathlength containing 3.5 ml of a solvent

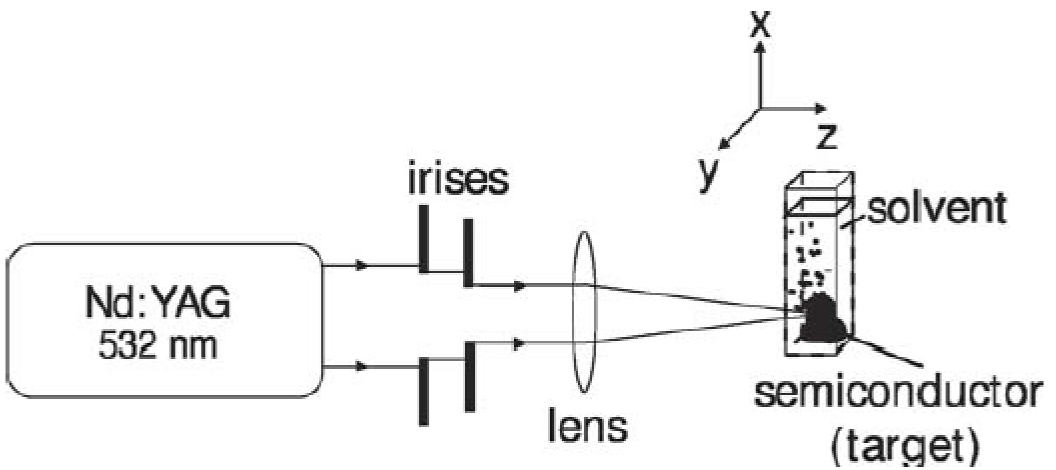
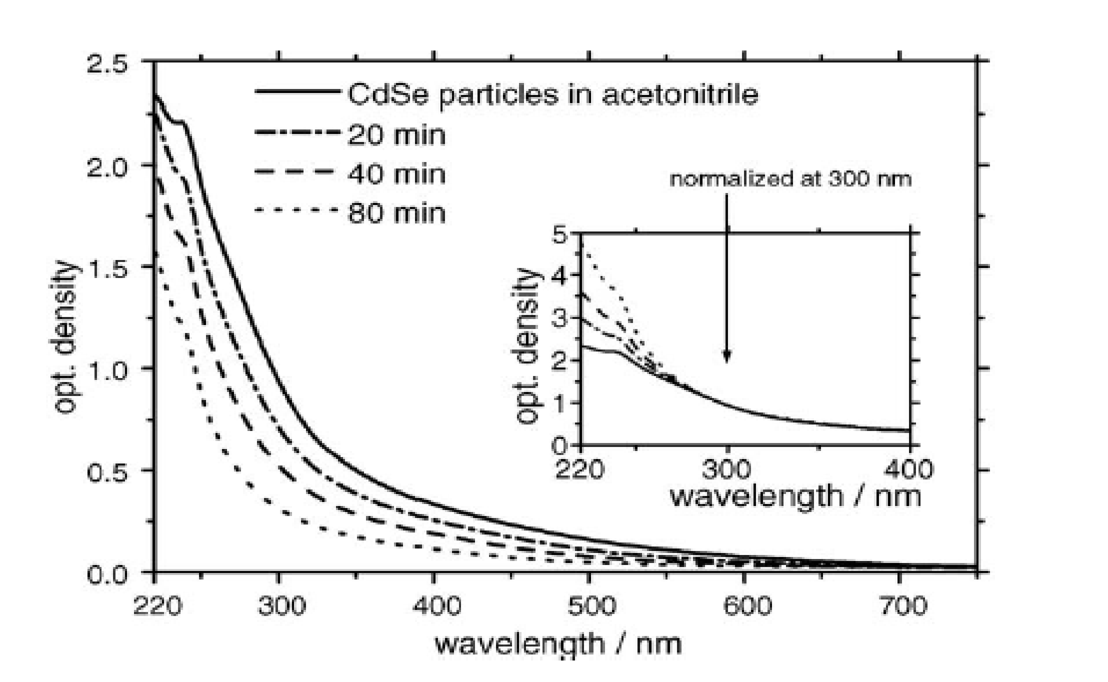


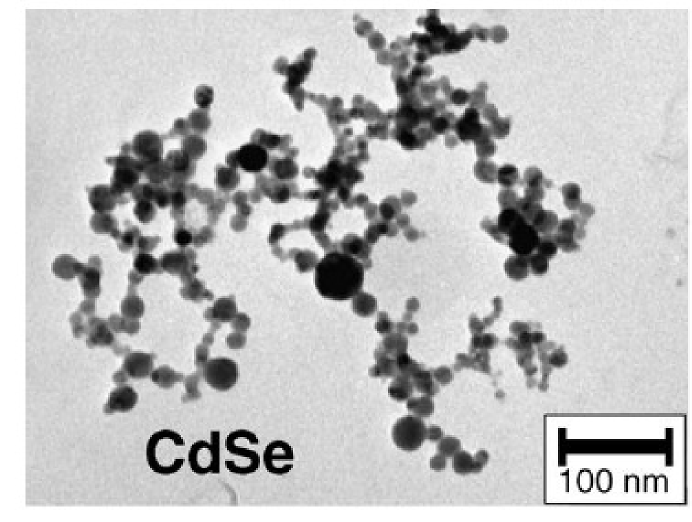
Fig. 1. Laser ablation setup schematically.

Solvents and sample preparation

(1) acetonitrile, 99.9%);
(2) acetone
(3) butan-2-ol
(4) ethanol (Merck,
(5) methanol
(6) triethyleneglycol
(7) water

Bulk CdTe was of cubic structure and consisted of 46.9% Cd and 52.9%





Methods of Nanowires

Lithography or Printing on a surface For instance Writing with tip of Atomic Force Microscopy	**Self Assembly of Nanowires on a surface** It Grows wires with few nanometer diameter and less than 10 nm distance directly on a surface
Chemical Deposition or Electrodeposition It uses a template that can be a nanoporous material that one side is conductor as a working electrod	**Nanowires can be made of Metals , Semiconductors like Galium Silicon and all kind of polymers**

Some application of nanowires

Nanowire Materials	Applications	Advantages
Pd	H_2 gas sensor	Quick respond time Operating at room temperature
Semiconducting oxides: ZnO, SnO_2, and In_2O_3	CH_4, NH_3, CO, NO_x, O_2 gas sensors	High sensitivity Works at room temperature (low power)
Cu	field emitter, heat controlling system	High magnetic resistant
Ag	Explosive and drug sensors	Online (real time) detection Fast response time Ultra sensitivity High selectivity
Bi	Magnetic field sensor, Biomagnetic sensors	Giant magneto resistance
Au	Detection of Mecurry in water, Biosensors	Online (real time) detection Fast response time High sensitivity

Techniques and Experiments

- Ion beam requirements
- Design and fabrication of ion beam with sufficiently reduced flux density (beam selection)
- Irradiatedof CR-39 detector with proton
- chemical etching and surfactant, ion track-etch detector to prepare nanostructures of desired shapes for nano-research
- Design and fabrication of electrolytic cell
- nano wire growth with electro depotions method
- AFM, XRD and SEM observation

Ion beam requirements

❖ **Proton (Korea Institute of Radiological & Medical Sciences (KIRAMS)**

Max energy: 30.4 MeV, min energy:15 MeV

Current: 1-500 μA

Beam diameter: 5mm

✓The minimum current intensity is about 1μA (10^{11}#/cm^2)which is still too intense.

✓ we describe the special requirements for preparing an ion beam with sufficiently reduced flux density(about 10^4 #/cm^2)

beam selection

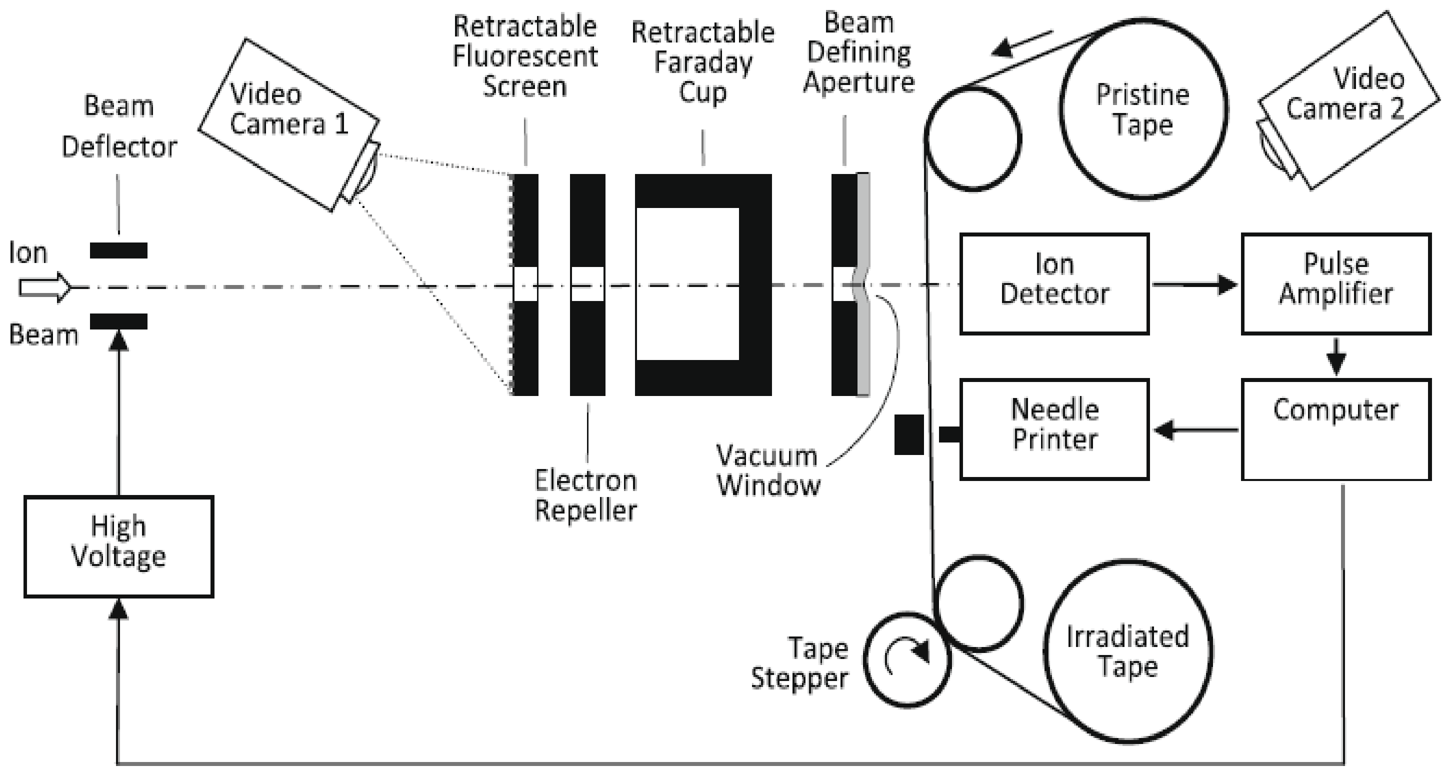


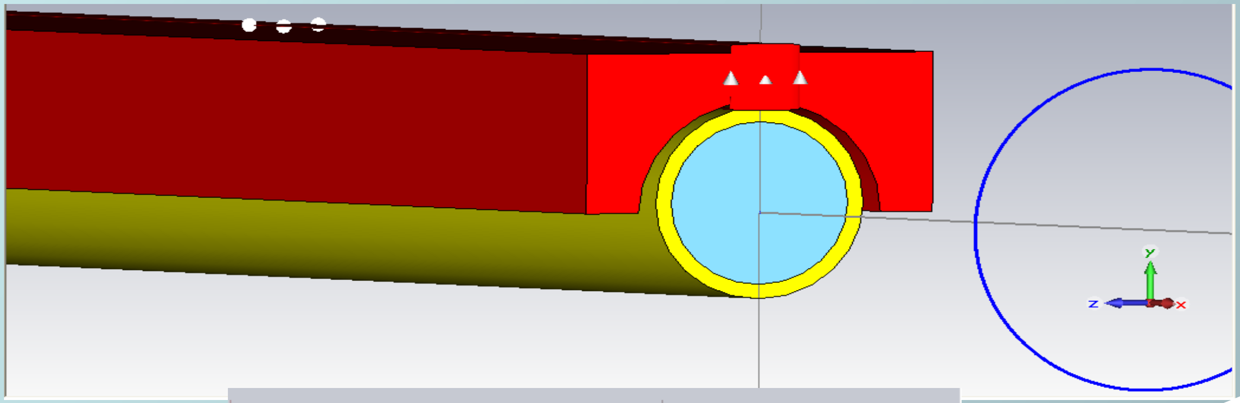
Fig. 2. Principle of tape transport system (developed at GSI Darmstadt for use at The Svedberg Laboratory of Uppsala University, Sweden; http://rsp.eunitt.de/: projects Controlled Fabrication of Micro Channels: thumbnails) consisting of beam deflector, beam diagnostics and tape transport. The high voltage supply and the beam deflecto (left) are integral parts of the ion accelerator.

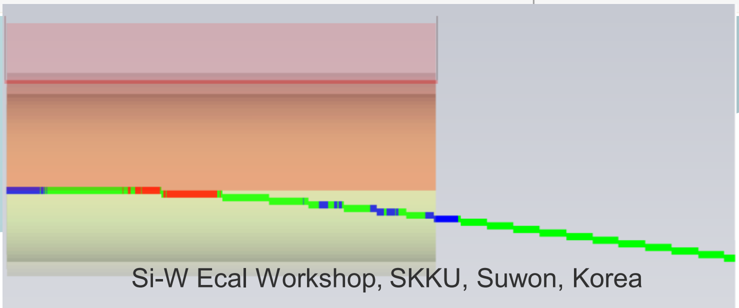
High voltage pulse generator

The minimum current intensity is about1μA which is still too intense. The irradiation time should be cut into100ns for the purpose of reducing the track density to10^4 cm2.

Magnetic field deflection

- Appropriate magnetic field is used for deflecting proton beam





range and energy for CR-39 detectors

- CR-39 detectors of thickness 1000, 700, 500 μm will be vertically irradiate with 20-30MeV proton beam

- specific energy lose (dE/dx) for CR-39 detector was calculated with SRIM code

Proton Energy(Kev)	Range	dE/dx(Kev/μm)
700	11.22(μm)	40.74
1000	19.51(μm)	32.45
2000	58.85(μm)	20.63
3000	115.91(μm)	15.20
20000	3.31(mm)	3.34
25000	4.95 (mm)	2.78
30000	6.88(mm)	2.4

Chemical etching and influence of Surfactant

- ✓Etching co detector in NaOH with appropriate concentration and temperature through the use of surfactant (Sodium Dodecyle Sulfate)

- ✓Study the effects of the acid and alkali resistant surfactant (Sodium Dodecyle Sulfate) on ion track etching at low etch rates and cylindrical pores

✓Study and calculation the Influence of surfactant concentration on

1- bulk etching rate

2- track etching rate

3- the radial etch rate

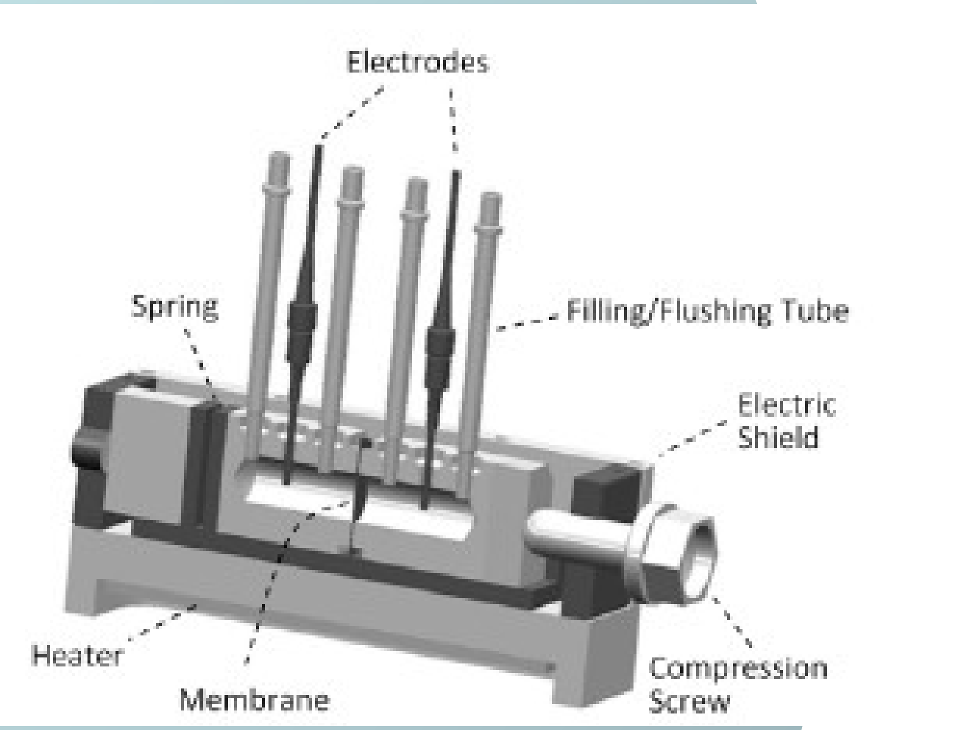
4- break through time

✓ Study the effects of ultraviolet (UV) irradiation, before etching, on the process of chemical development of ion tracks in CR-39

✓ Find the optimum parameter by controlling the irradiation characteristics, etching time and the concentration of etchant, surfactant

Design and fabrication of electrolytic cell

- Electrolytic cell consisting of two identical cell
  Size of electrolytic cell about few centimeter
- Main part of cell in order to etching and electro replication made of PTFE
- The metal housing of the cell serves as an electrical shield and acts at the same time as a thermal shield

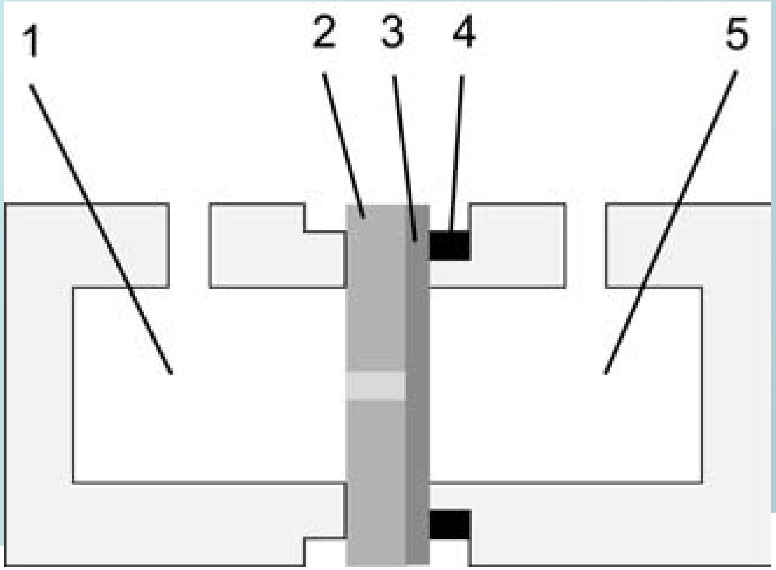


- The electrodes and filling/flushing tubes are accessible during operation through a slit

Chemical etching in electrolytic cell

✓The first step is the sputter deposition of a gold film *on one* side of the CR-39 detector

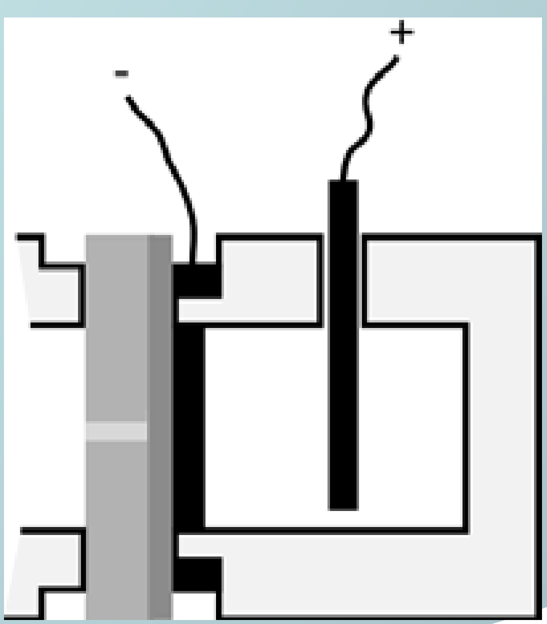
✓Then, the detector that irradiated with proton beam is inserted into an electrolytic cell consisting of two chambers



Electrolytic cell used for wire **deposition:**

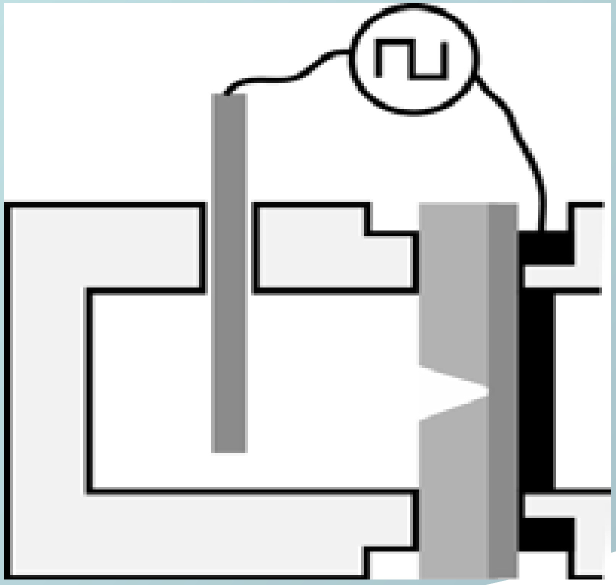
(1) left chamber,
(2) CR-39 detector,
(3) Sputtered gold film,
(4) copper ring,
(5) right chamber

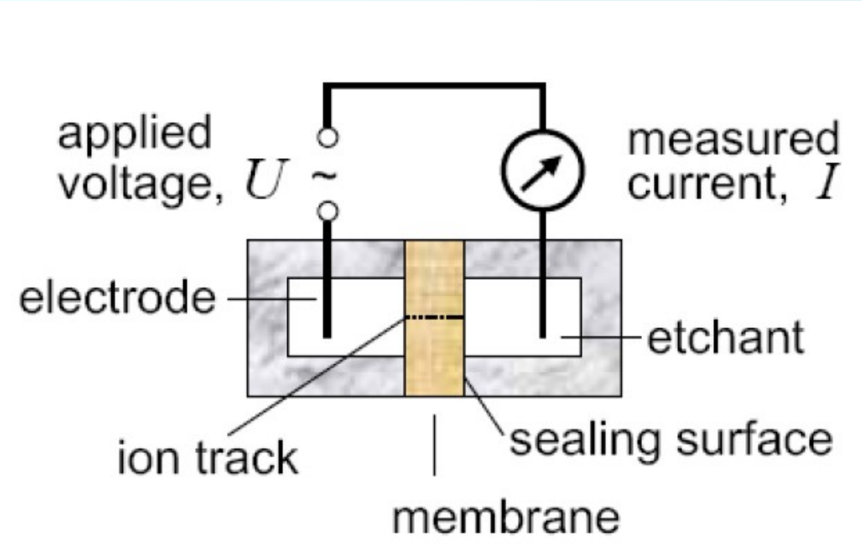
✓The mechanical stability of the gold film is strengthened by electrodepositing a copper layer in the right cell chamber



✓The left chamber is filled with the etching solution containing different amounts of NaOH and Surfactant

✓Apply a voltage between a gold wire immersed in the etching solution and the metallic layer deposited on the back of the detector. Measure an electric current as soon as the detector is completely etched through

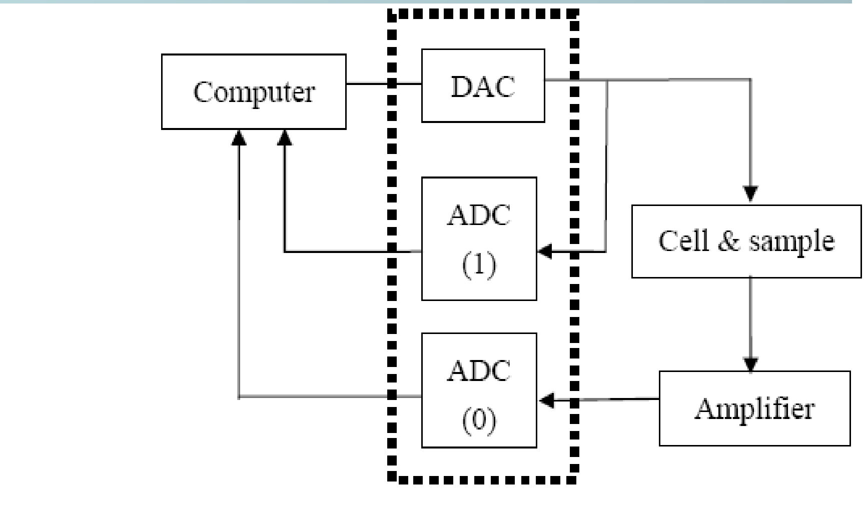




✓the data acquisition system

✓The computer controls the data acquisition card, which converts the digital signal from the computer into an analog voltage, which is applied to the conductometric cell.

✓The current through the etched ion track channel is measured and analyzed



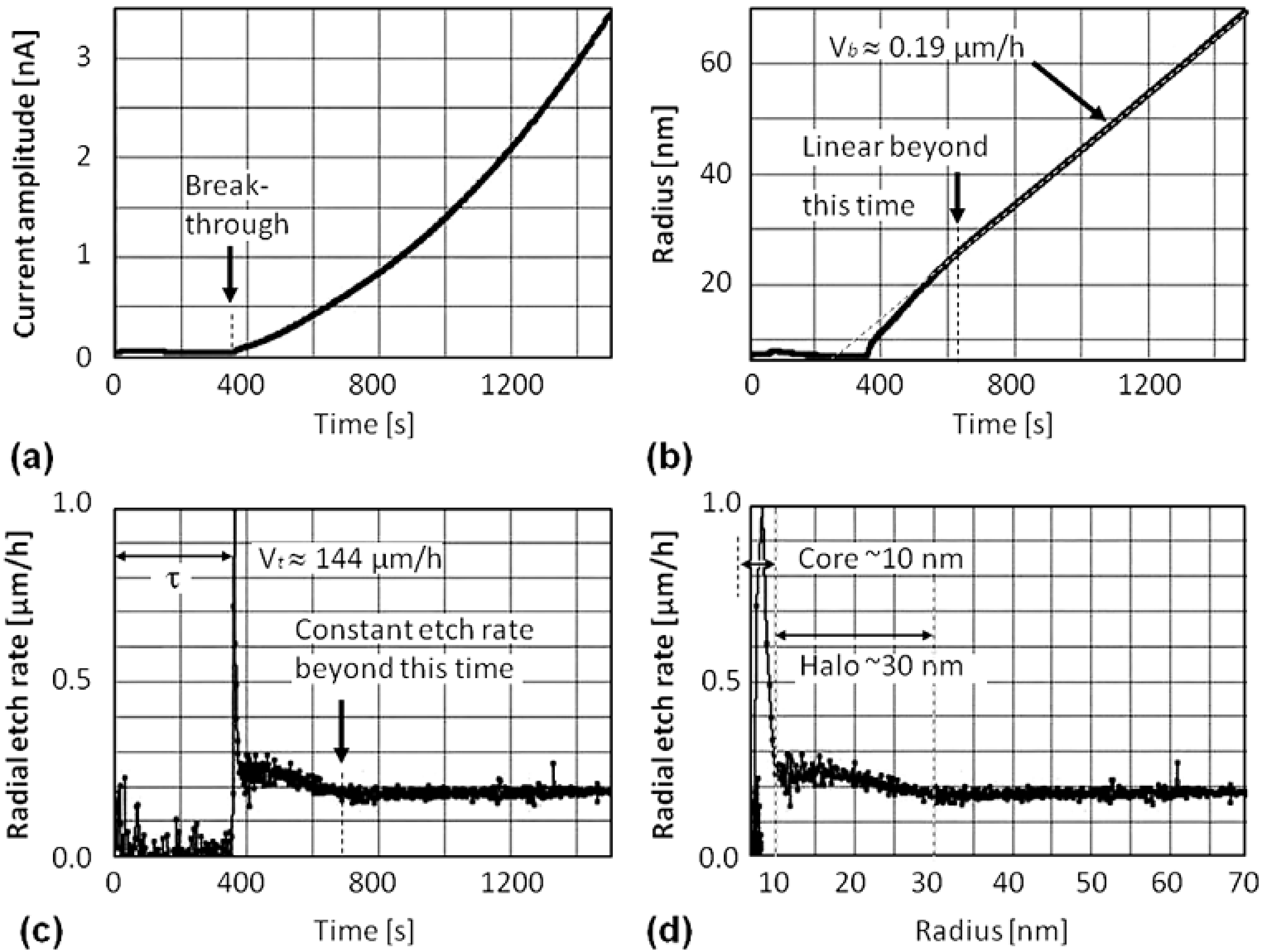
Data analysis of electrolytic cell

We can obtain with data analysis:

- ✓current measurement as function of time,
- ✓track radius as function of time,
- ✓radial etch rate as function of time, and
- ✓radial etch rate as function of radius
- ✓break through time

↓

- ✓Track and bulk etch rates are determined in real-time
- ✓If the number of tracks and their length, as well as the conductivity of the etchant is known, the radial etch rate can be determined
- ✓Stop etching at a preset value of the track diameter by activating an electrical valve


Current amplitude [nA]
Break-
through
Time [s]
(a)
Radius [nm]
Vb ≈ 0.19 µm/h
Linear beyond
this time
Time [s]
(b)
Radial etch rate [µm/h]
τ
Vt ≈ 144 µm/h
Constant etch rate
beyond this time
Time [s]
(c)
Radial etch rate [µm/h]
Core ~10 nm
Halo ~30 nm
Radius [nm]
(d)

Preparing and manipulating cylindrical micro and nano wires in electrolytic cell

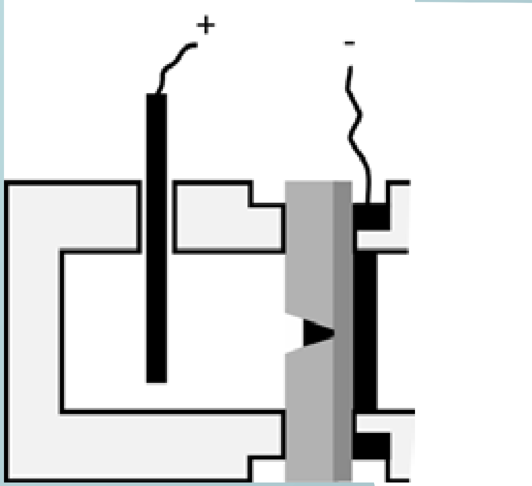
- After etching CR-39 detector, solution is removed from the cell automatically

- the chamber is carefully washed with distilled water

- the chamber is filled with the solution employed for electrodeposition (in order to copper nano wire growth, *Cu2SO4 · 5H2O* and *H2SO4).*

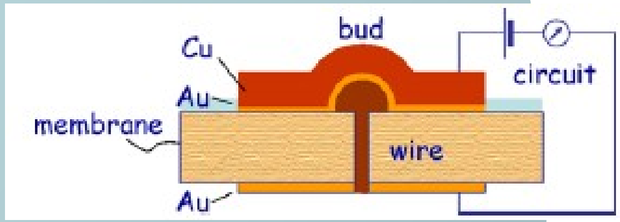
- A two-electrode arrangement is used for electrodeposition

❑The wire is grown at a few hundred -mV potential difference between the two electrodes



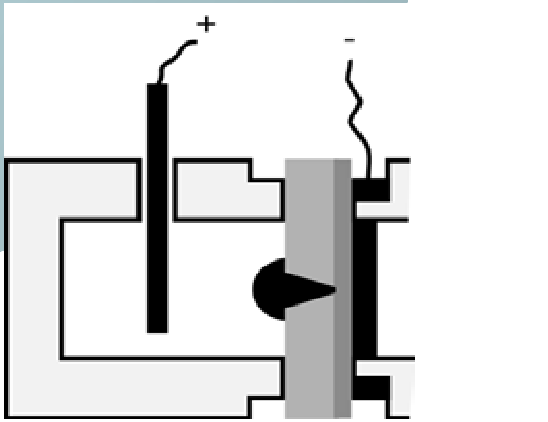
❑ start nano wire growth

The currents during etching and wire growth were measured using a picoammeter



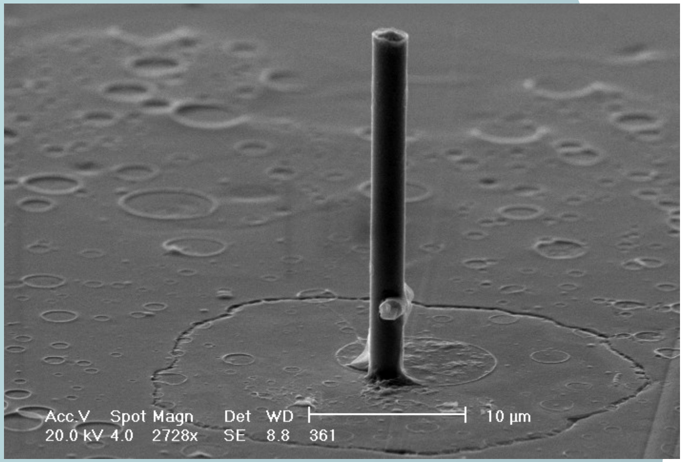
❑When the wire reaches the detector surface, a cap grows on top

❑ by analyzing the current recorded during wire growth in a pore, the processing of wire growth correspond to during pore filling, complete pore filling and the beginning of cap growth

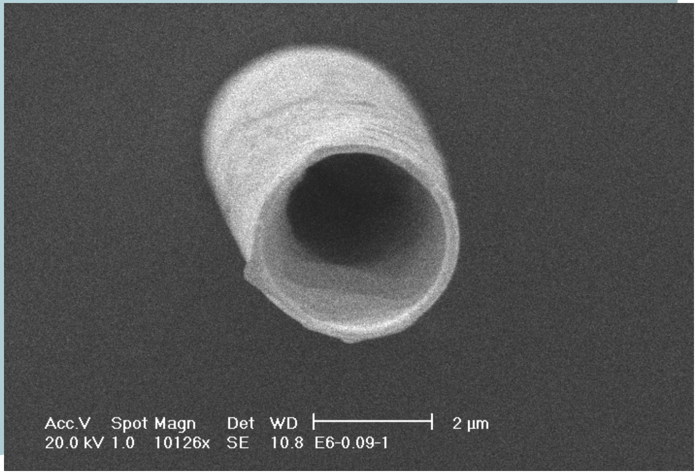


❑Depending on properties of detector, etching time, concentration of surfactant , applied voltage during the electro deposition and … we will be obtained solid wires or hallow wires

solid wire

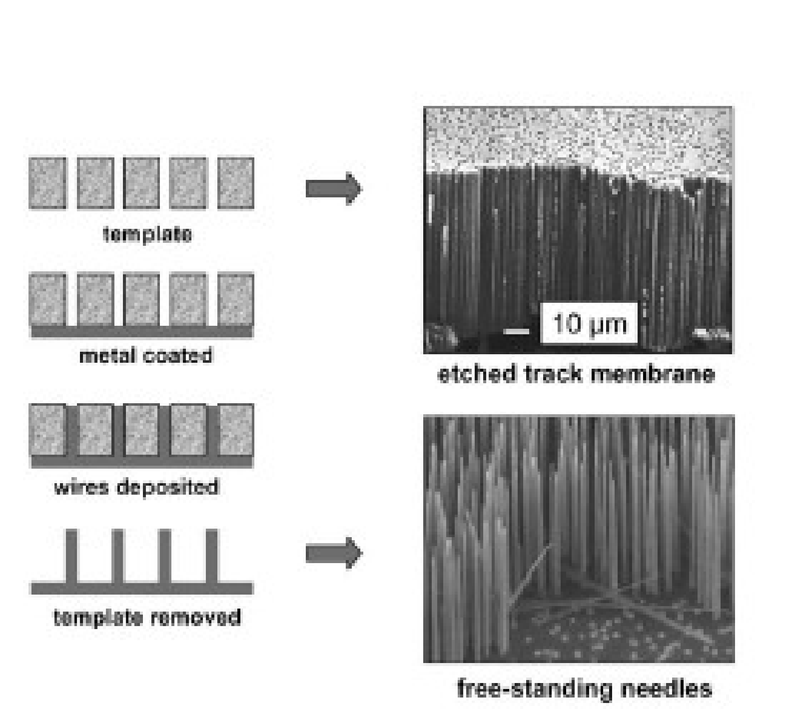


Hallow wire



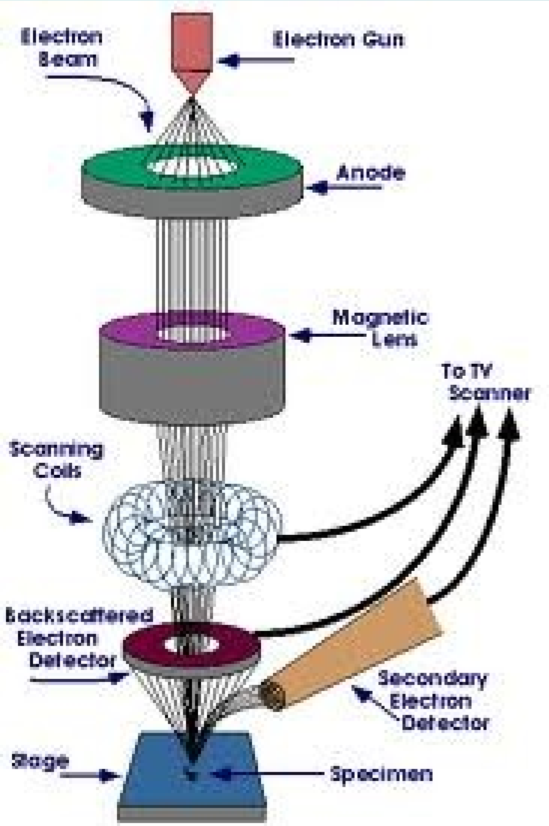
❑After completion of the growth process, the sample is removed from the cell and rinsed with distilled water

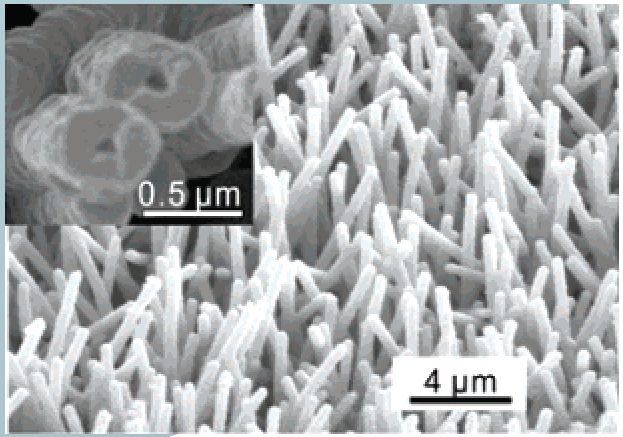
❑Dissolving the detector in appropriate solution, wires will be visualized (dichloromethane)



❑SEM observations

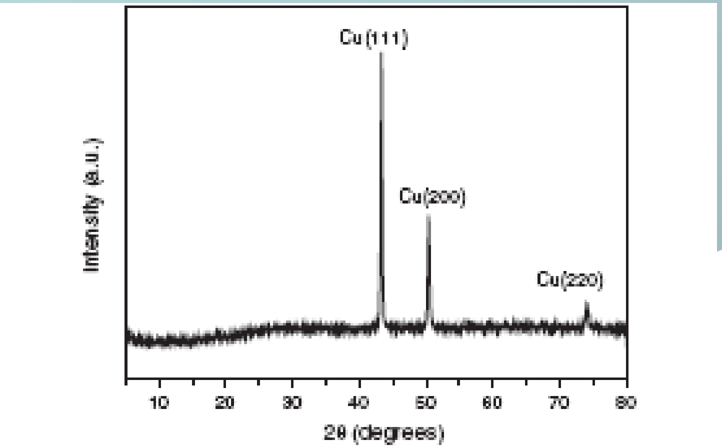
✓Wire shapes resulting from several etchant concentrations and from different etching times were inspected by SEM





❑XRD observations

✓The preferred growth for the copper nanowires is the direction, which was determined from the XRD pattern



❑AFM observations

✓ With the CS-AFM , I–V curves of hundreds of individual copper nanowires will be investigated quickly

✓ study behavior of CU nanowires ohm`s law observation