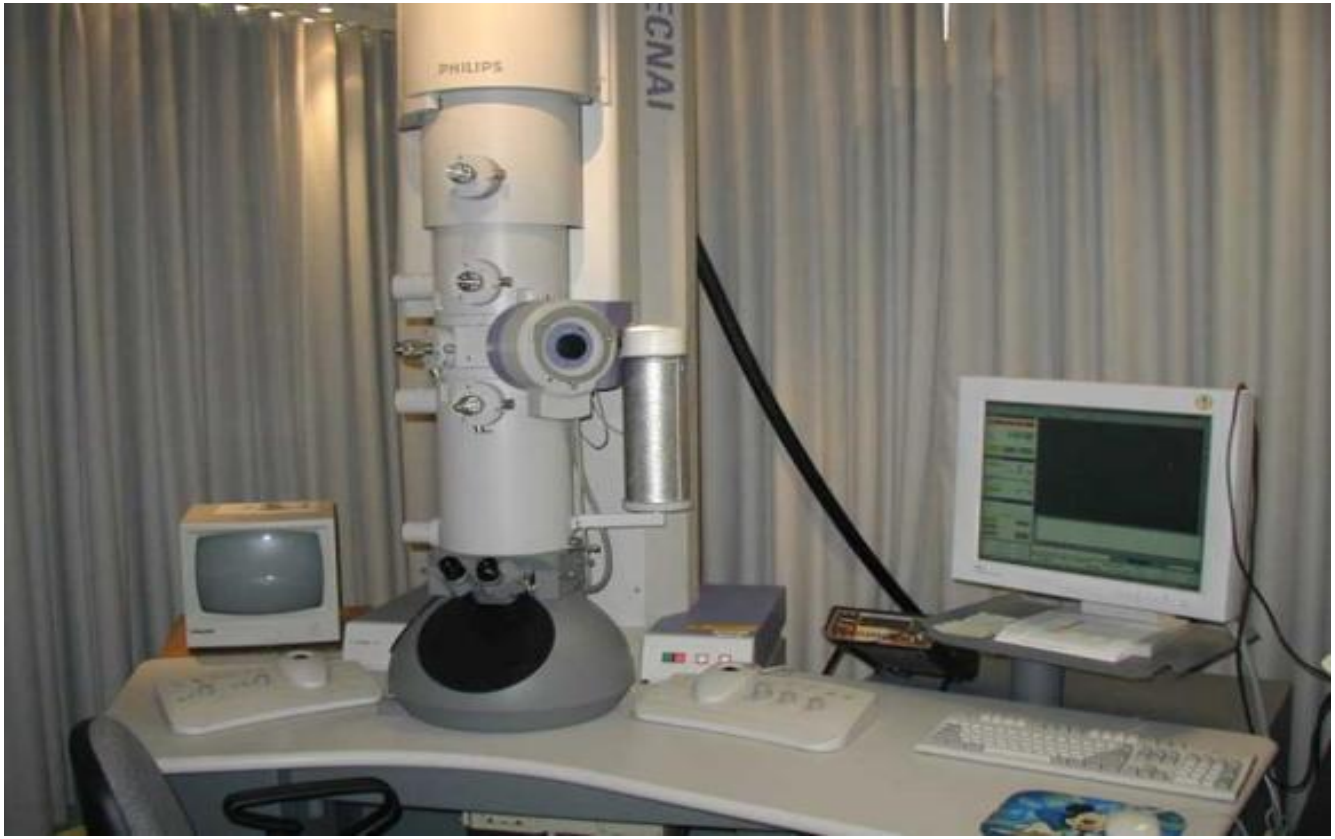
FIELD EMISSION MICROSCOPE (FEM)



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MATERIAL SCIENCE AND TECHNOLOGY

FIELD ION MICROSCOPE (FIM)

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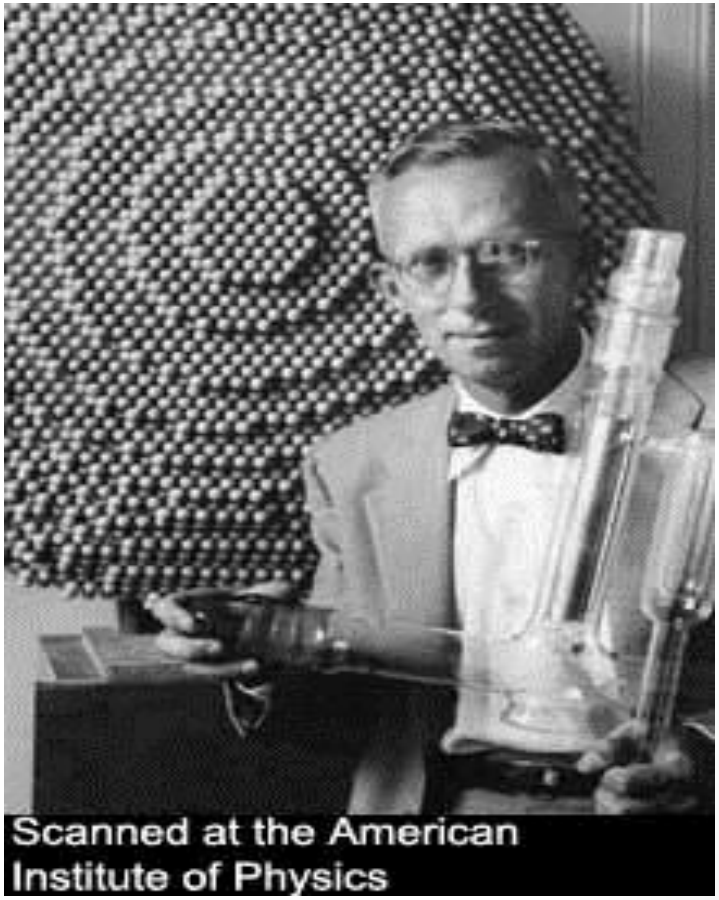
FIELD EMISSION MICROSCOPE (FEM)

History of FEM

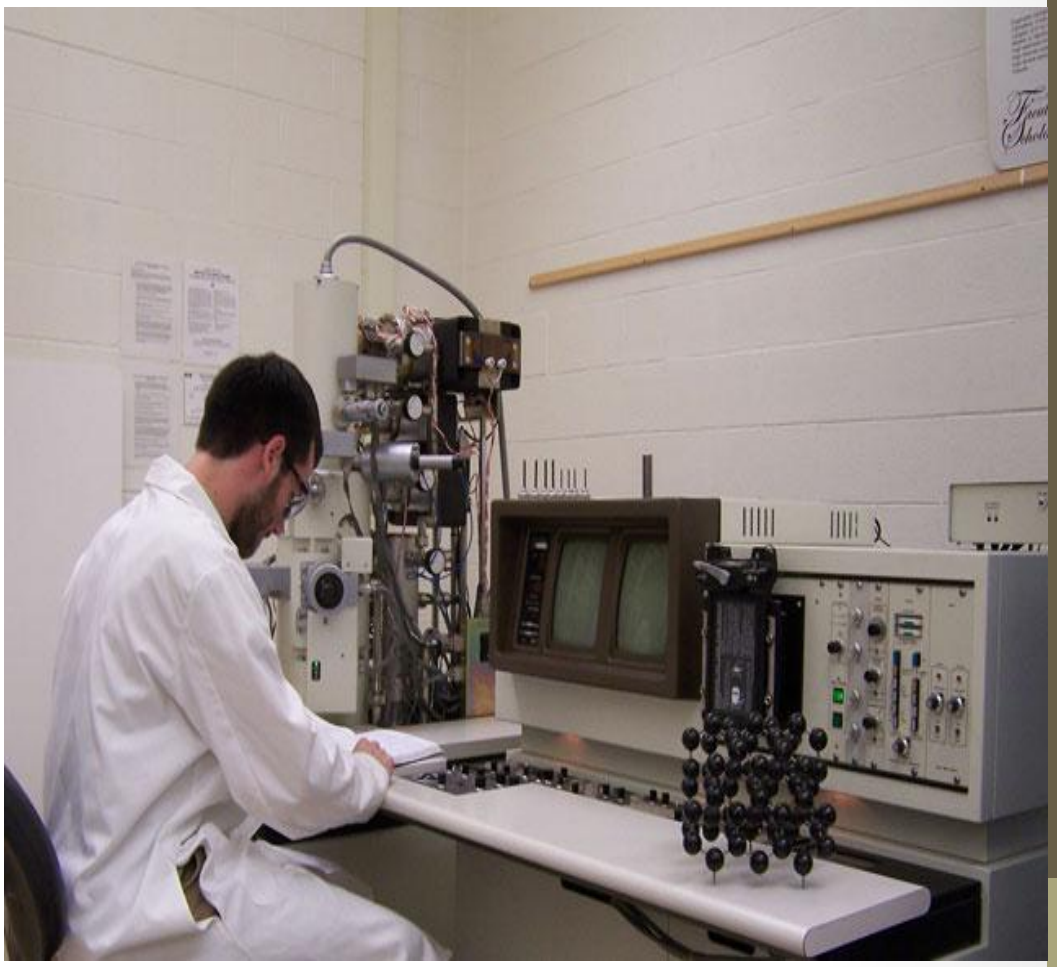
- The field emission microscope was invented by Erwin Mueller in 1936.
- He was the first person to experimentally observe atoms.



Picture 1- Erwin Mueller

What is FEM ?

- Field emission microscopy (FEM) is an analytical technique used in materials science to investigate molecular surface structures and their electronic properties.



Picture 2- Field Emission Microscope

What is FEM ?

- FEM was one of the first surface analysis instruments that approached near-atomic resolution.

- This instrument approached to view a surface on a scale of atomic dimensions and yet simultaneously allowed one to follow rapid changes at the surface.

How it works?

In its simplest form, FEM consist of a sharp needle emitter and a fluorescent screen as shown in Fig. 1. By applying negative field to the emitter, electrons are emitted from the surface of the emitter to the direction of the screen. The image contrast appears due to the difference in current densities of electron, which originated from the difference in work functions and electric field on the emitter surface

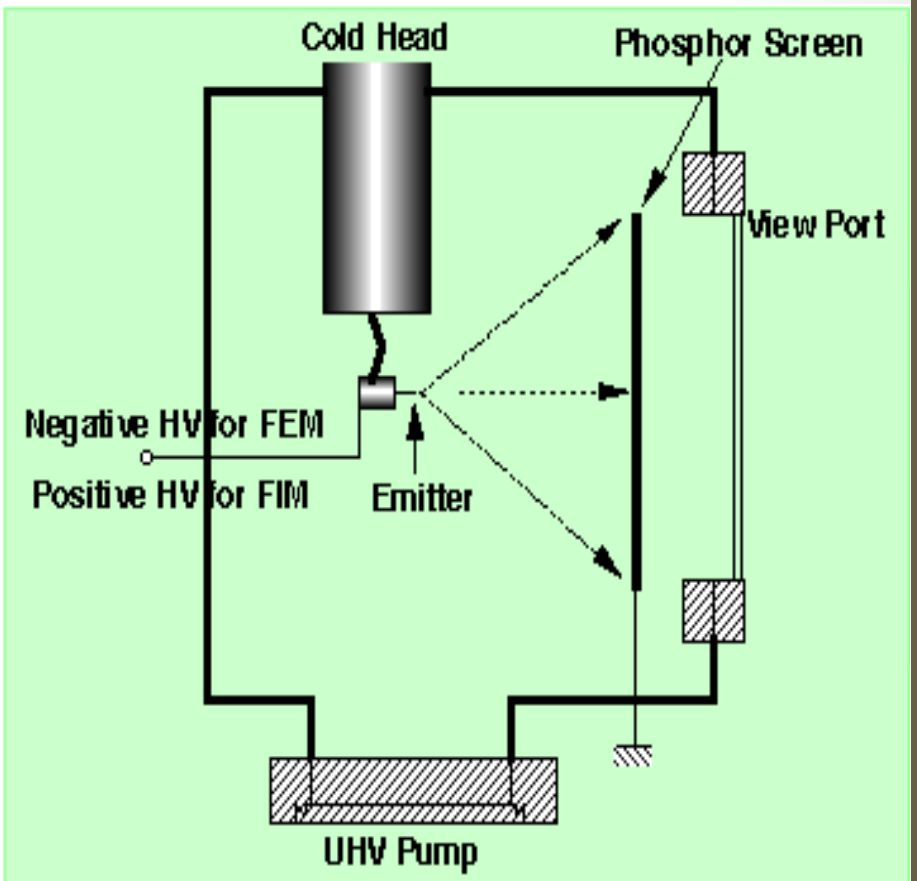


Fig. 1 Schematic drawing of field emission microscope (FEM) and field ion microscope (FIM).

Instrumentation

- Fluorescent Screen
- Metallic sample in the form of a sharp tip
- Ultra high vacuum (UHV), pump
- Power supply

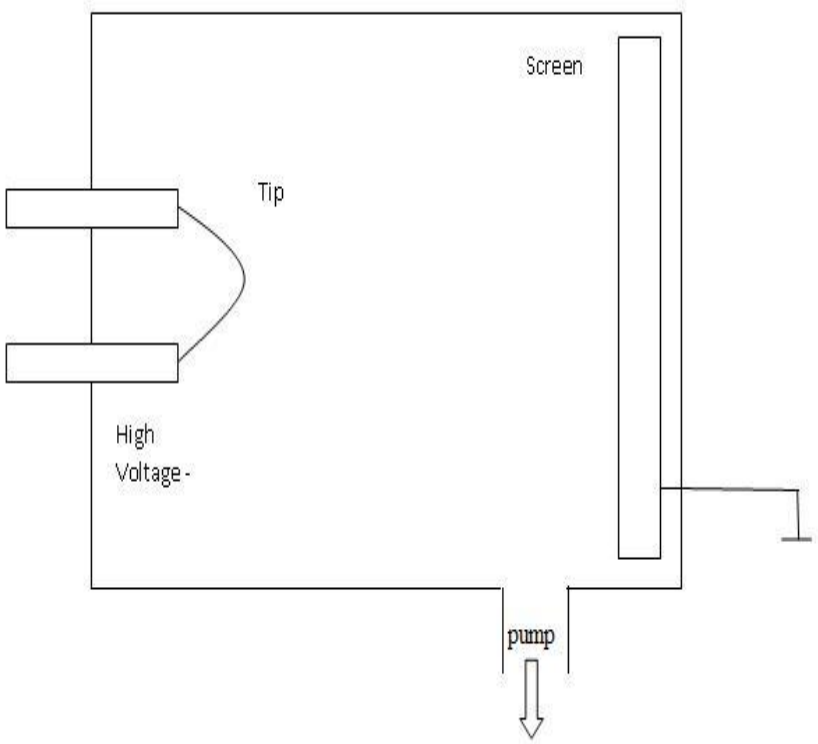


Fig.2:FEM experimental set-up

Working conditions

- Requires a very good vacuum (ultra high vacuum)
- Emission is not due to the clean surface.
- No vibrations
- Tip materials can tolerate the high electrostatic fields and have high melting points

Applications

- **Surface Science (Electronic and Structural aspects)**

Field emission has been extensively used in the characterization of surface structures and electronic properties.

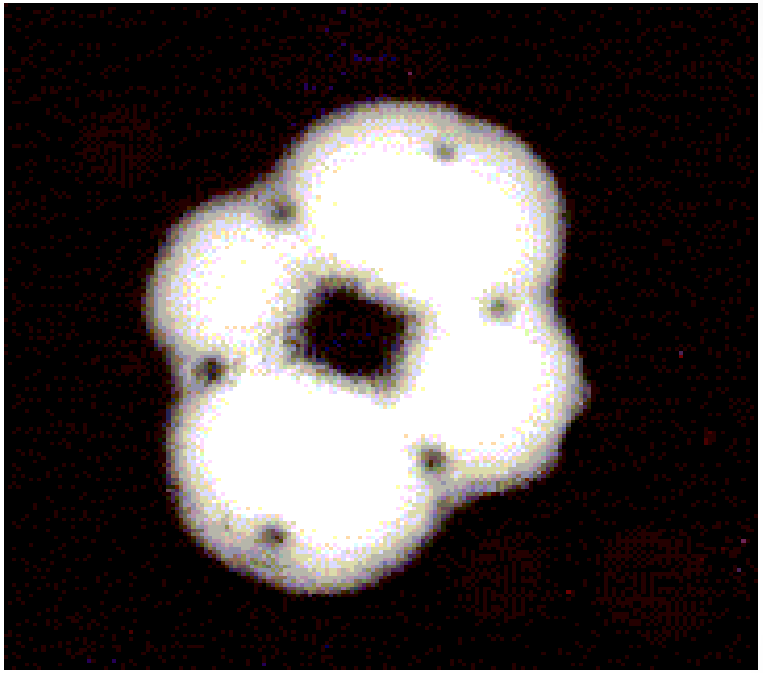
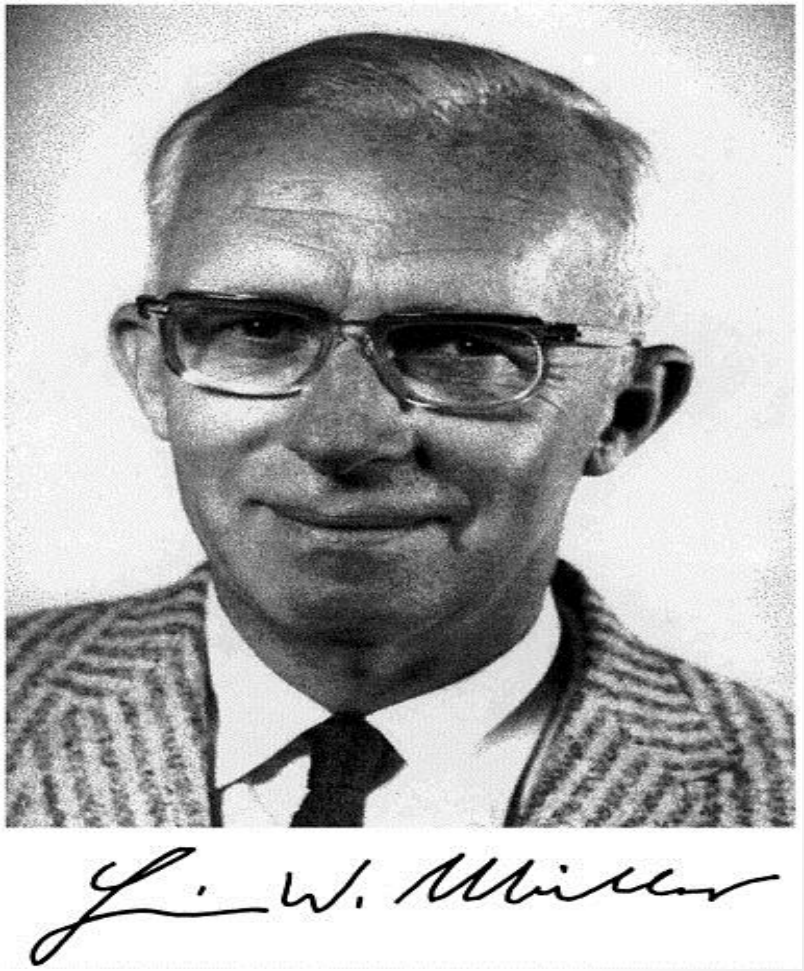


Fig.3-Field emission Micrographs of a clean tungsten single crystal surface

FIELD ION MICROSCOPE (FIM)

History of FIM

The idea of FIM really comes from Prof. E.W. Mueller. It all began in 1951 when Mueller published his FIM paper, describing the invention of FIM and its improved resolution compared to FEM.



Pic.4- E. W. Mueller

What is FIM ?

- The field ion microscope is a type of microscope that can be used to image the arrangement of atoms at the surface of a sharp metal tip.
- It was the first technique by which individual atoms could be spatially resolved.

Pic.5- field ion microscope

How it works?

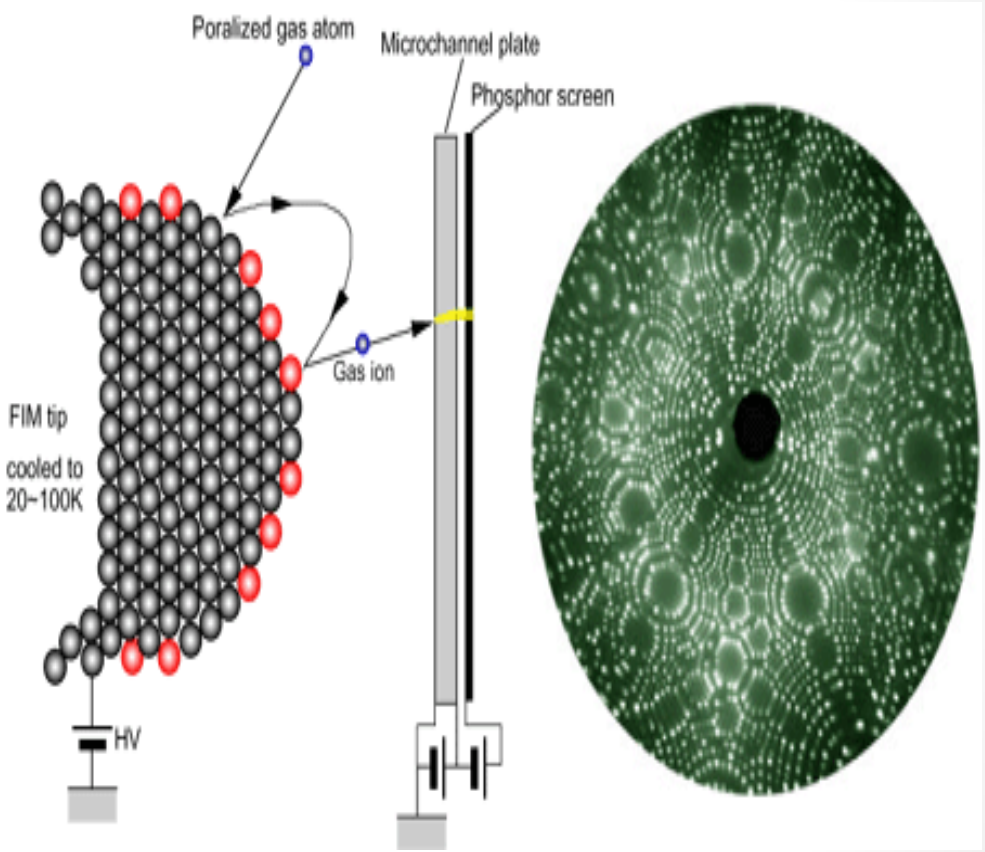
- The imaging gas atoms (He, Ne) near the tip are polarized by the field and since the field is non-uniform the polarized atoms are attracted towards the tip surface.

- The imaging atoms then lose their kinetic energy performing a series of hops and accommodate to the tip temperature.

Pic.6- FIM image formation process.

How it works?

- Eventually, the imaging atoms are ionized by tunneling electrons into the surface and the resulting positive ions are accelerated along the field lines to the screen to form a highly magnified image of the sample tip.



Pic.7- Principle of field ion microscope (FIM)

Instrumentation

- Fluoresent Screen
- Microchannel plate
- Image gas (neon, helium and argon)
- Metallic sample in the form of a sharp tip
- Ultra high vacuum (UHV), pump
- Power supply
- Cooling agent (liquid nitrogen)

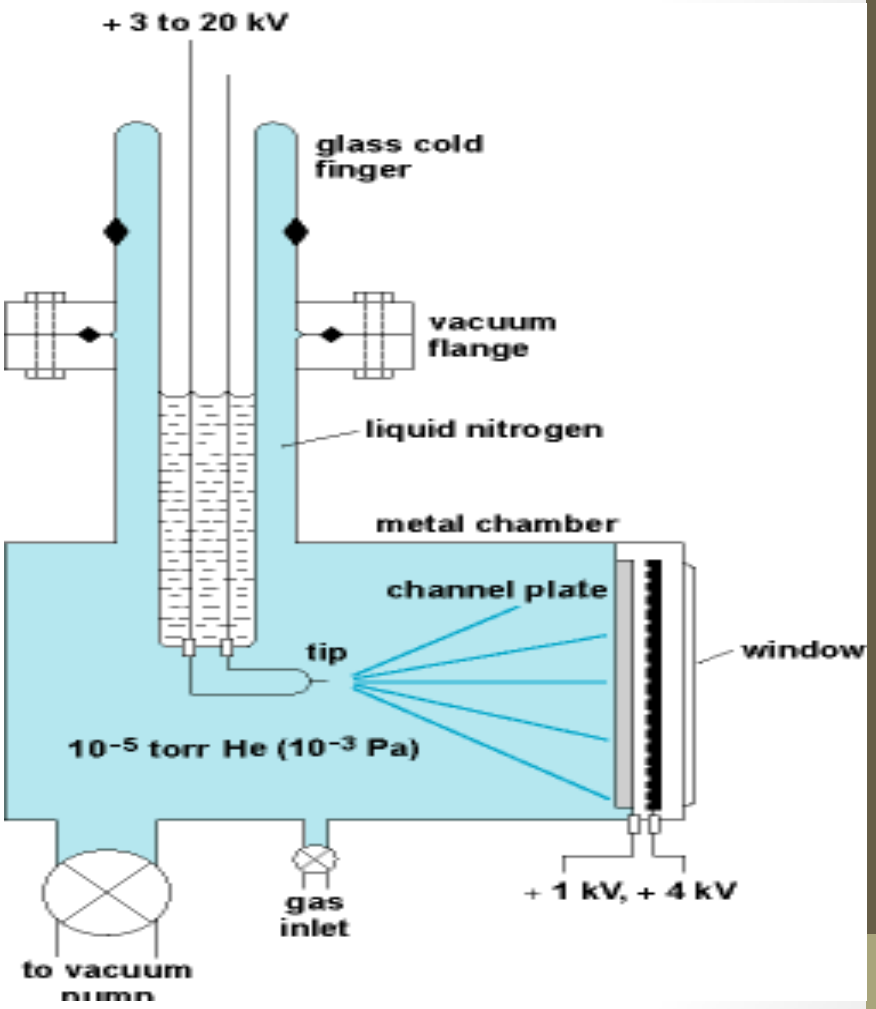


Fig.3- Field ion microscpy

Working conditions

- FIM like Field Emission Microscopy (FEM) . Both have same working conditions.

However, there are some essential differences as follows:

- The tip potential is positive.
- The chamber is filled with a imaging gas (typically, He or Ne at 10^{-5} to 10^{-3} Torr).
- The tip is cooled to low temperatures (~20-80K).

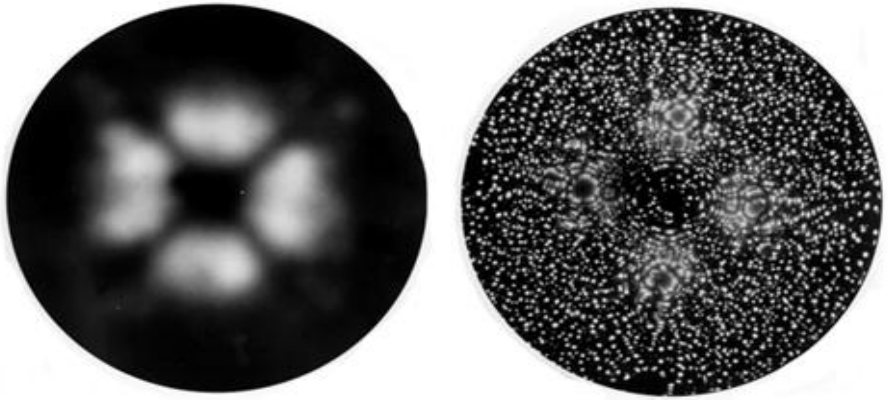
Applications

- FIM has been used to study dynamical behavior of surfaces and the behavior of adatoms on surfaces.

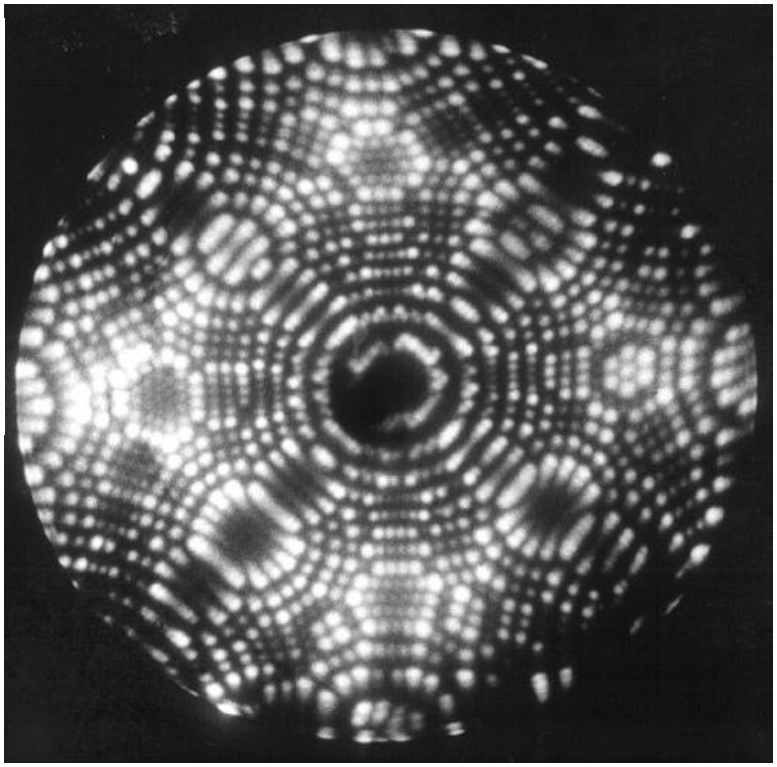
The problems studied include:

- Surface diffusion of adatoms ,
- Adatom-adatom interactions,
- Step motion,
- Equilibrium crystal shape, etc.

Examples of FEM and FIM



Pic.6- FEM and FIM images of a clean Ni surface. Both images were obtained from the identical surface of a Ni tip.



Pic.7- Field ion microscope image of Platinum. Each tiny bright spot corresponds to a platinum atom. Image was taken from the sample cooled to liquid He temperature with imaging gas of He-Ne mixture.

Summary

- **Field ion microscopy** (FIM) and **Field emission microscopy are**(FEM) are very important analytical techniques used in materials science to investigate molecular surface structures and their electronic properties.

- As you can see Erwin Wilhelm Mueller has great contribution for material science.

References

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