Electron diffraction

Studying crystal structure using wavelike phenomena of the electrones.

Anastasija Cumika

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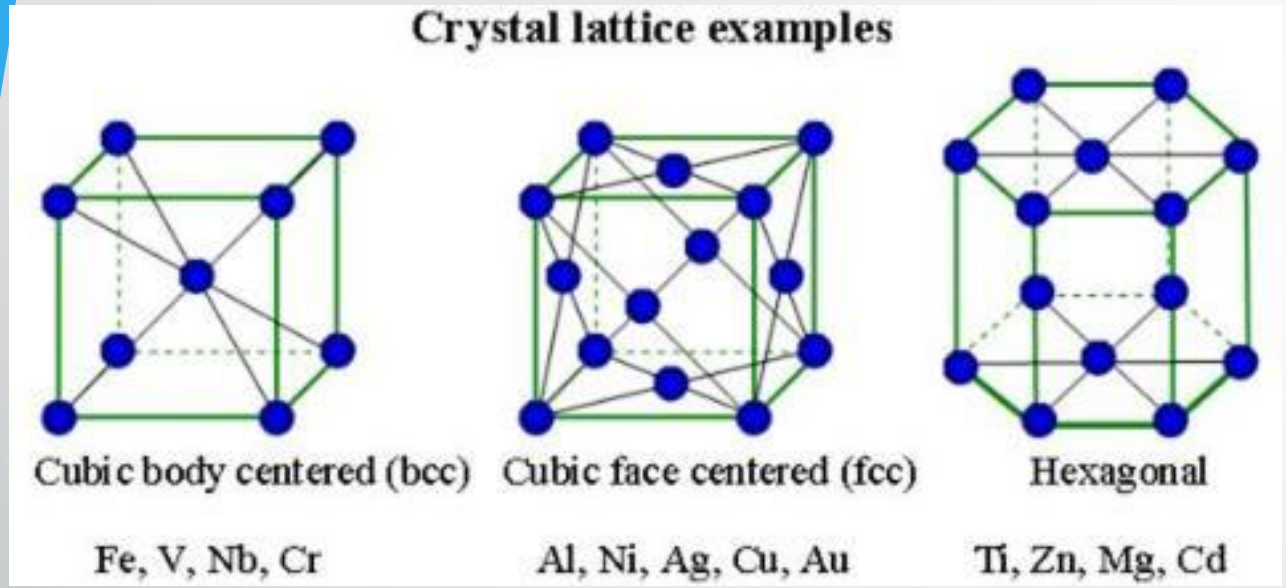
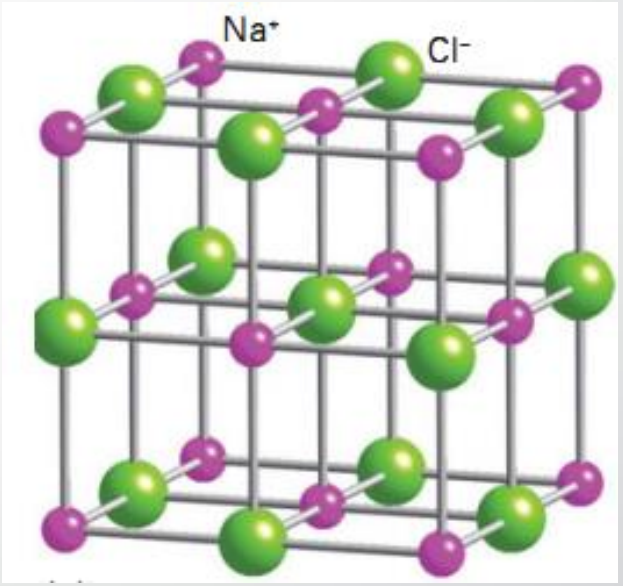
Outline

- Crystals' structure
- Electron diffraction theory: Wave-particle duality,Bragg's Law
- Techniques and equipment used for electron diffraction
- Electron diffraction images
- Limitations and advantages

Crystals

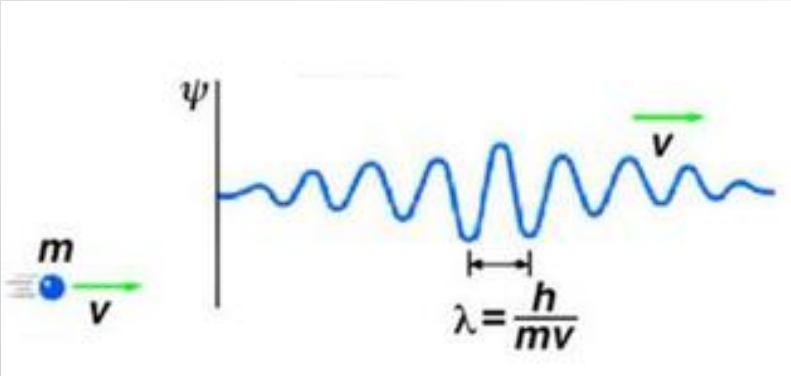




- Crystals are build of a periodic array of atoms or groups of atoms.
- The spacing between the atoms are in the order of a few angstroms

Wave-Particle duality

Louis de Brogile, 1924 – matter can behave like a wave.

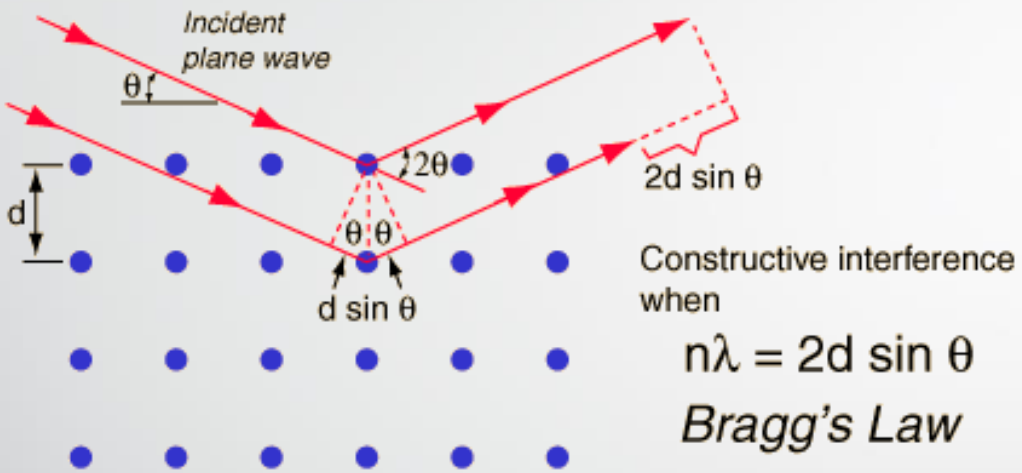


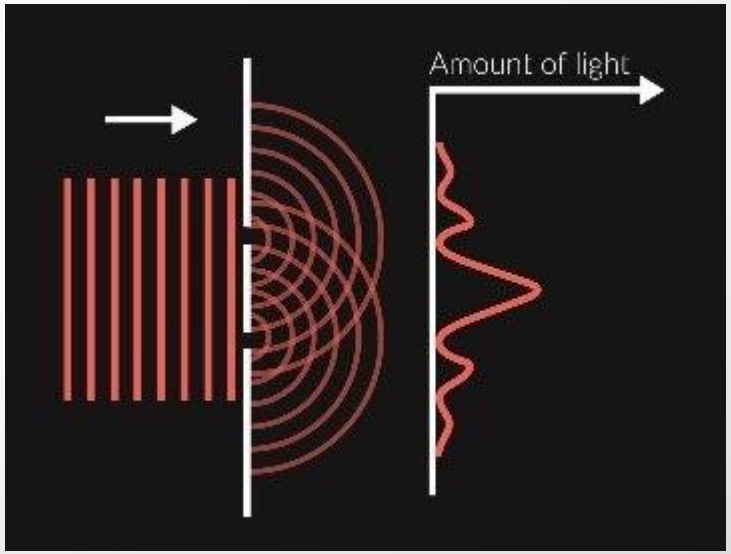
$$\lambda = \frac{h}{\sqrt{2m_0E\left(1+\frac{E}{2m_0c^2}\right)}}$$

Electrons with bigger momentum have smaller wavelength.

To get a small wavelength, electrons are accelerated to the speed that requires relativistic approach.

Bragg's Law

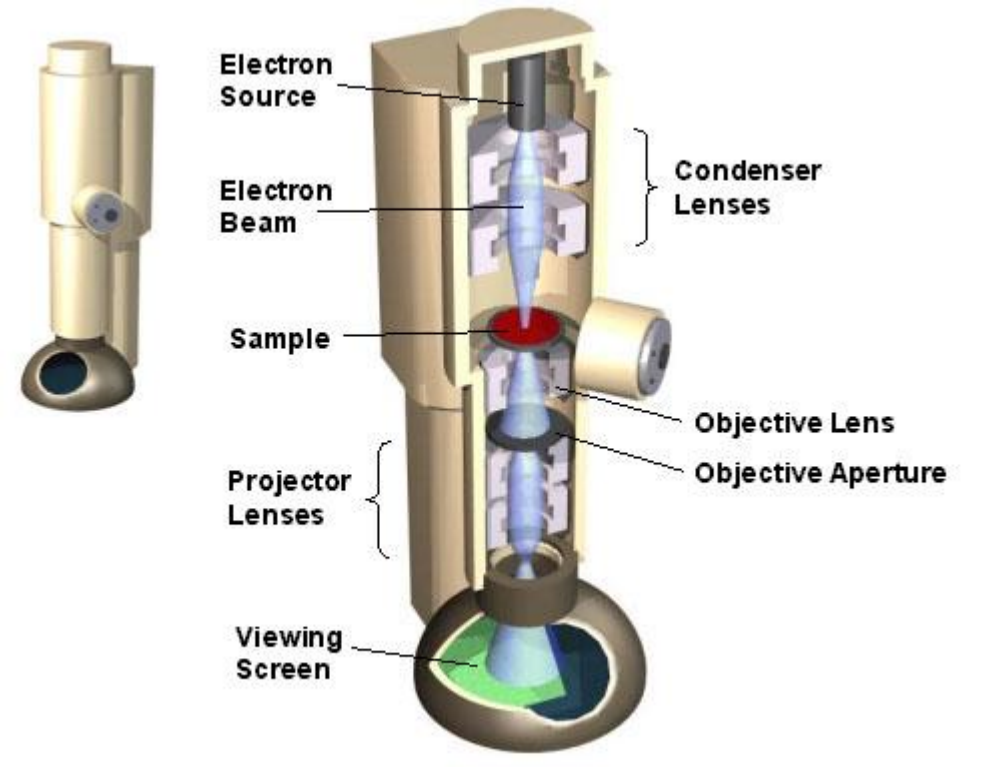




The periodic structure of crystals acts as a diffraction grating for the electron beam causing an interference.

Transmission Electron Microscopy

Max Knoll and Ernst Ruska,1931



Acceleration voltages 100-300 keV

Images of electron diffraction

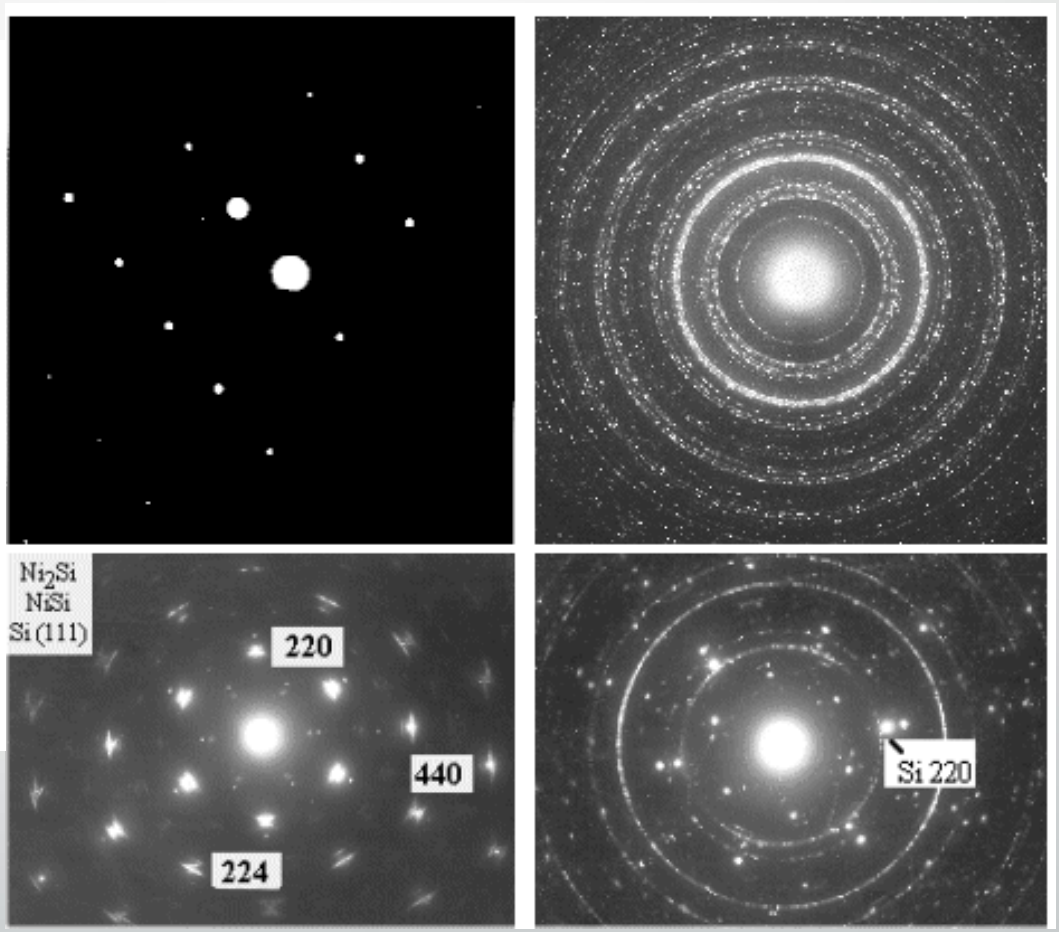
Diffraction patterns with an electron beam

Aluminum single crystal (Al)

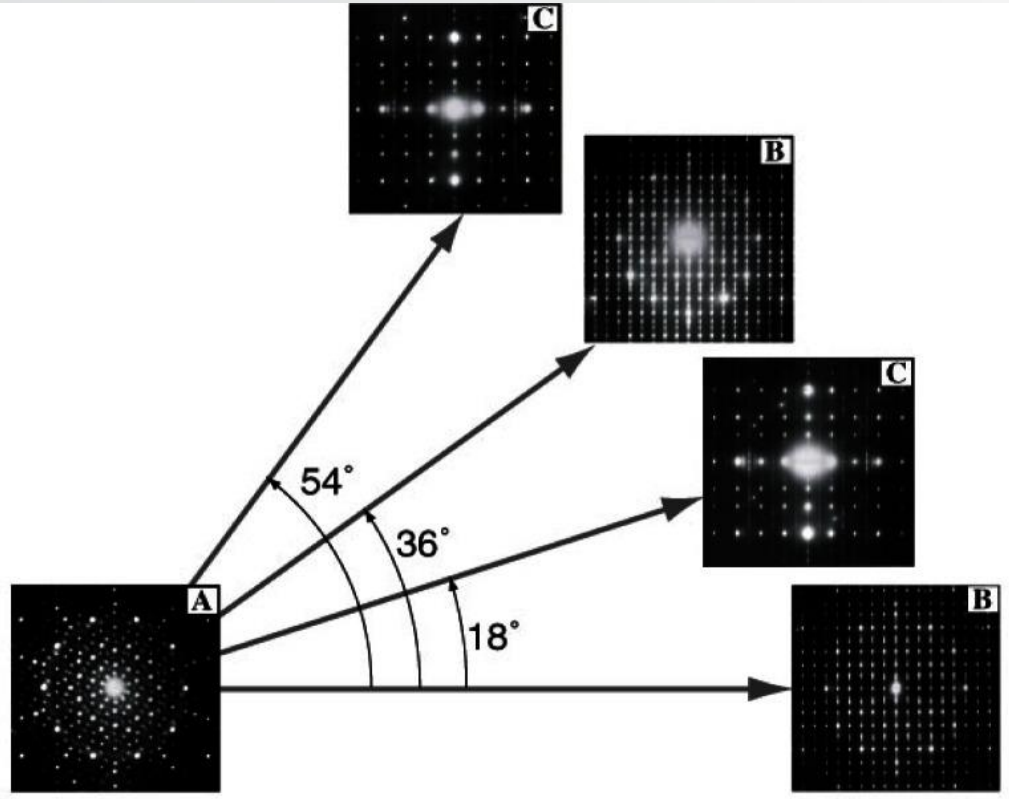
Polycrystalline platinum silicide (PtSi)

Silicon with epitaxial nickel silicides (Si - NiSi - $NiSi_2$)

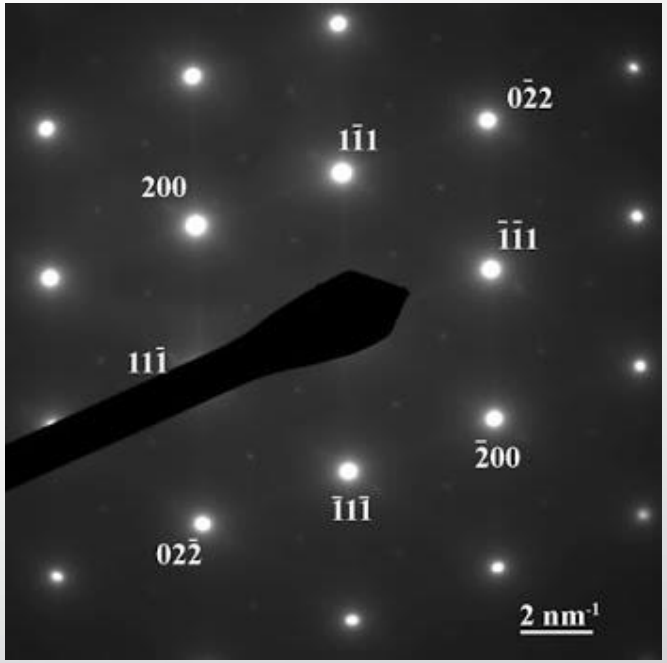
Polycrystalline nickel mono silicide (NiSi) on top of single crystalline silicon (Si)



Images of electron diffraction

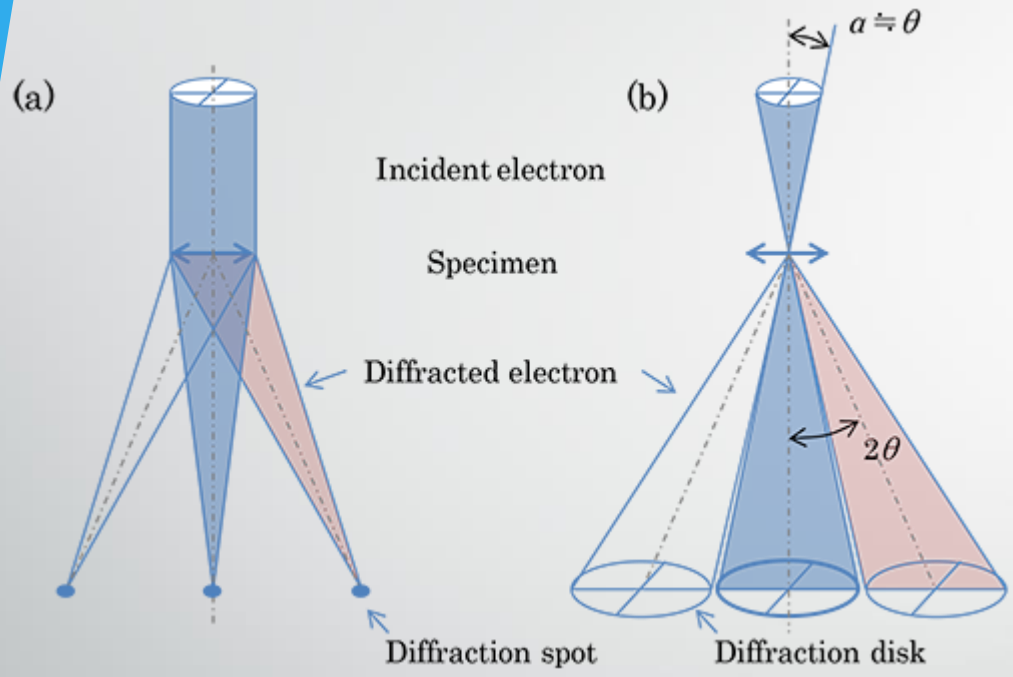


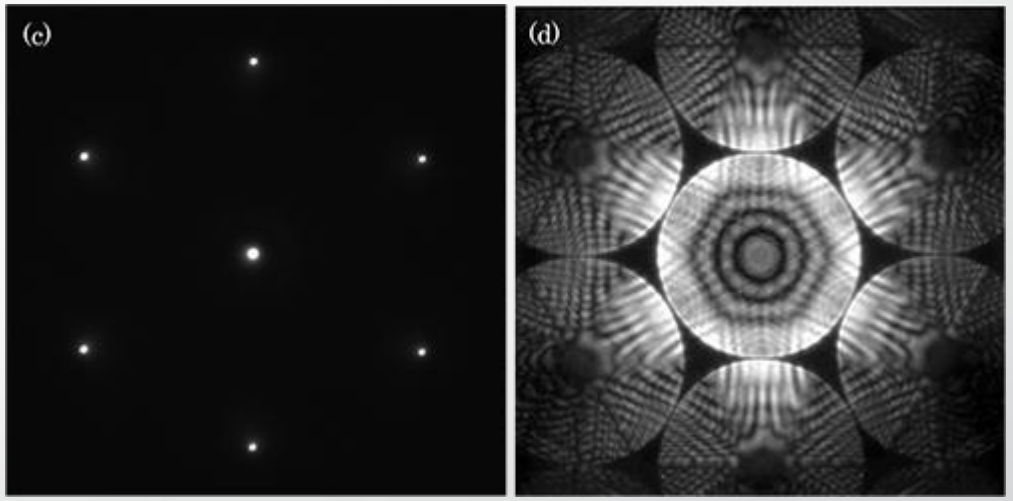
By tilting the sample we can observe the diffraction patterns from several crystal orientations to get the 3D image



Advanced analytical techniques used to examine solids depending on diffraction patterns

Convergent and non convergent beam of electrons





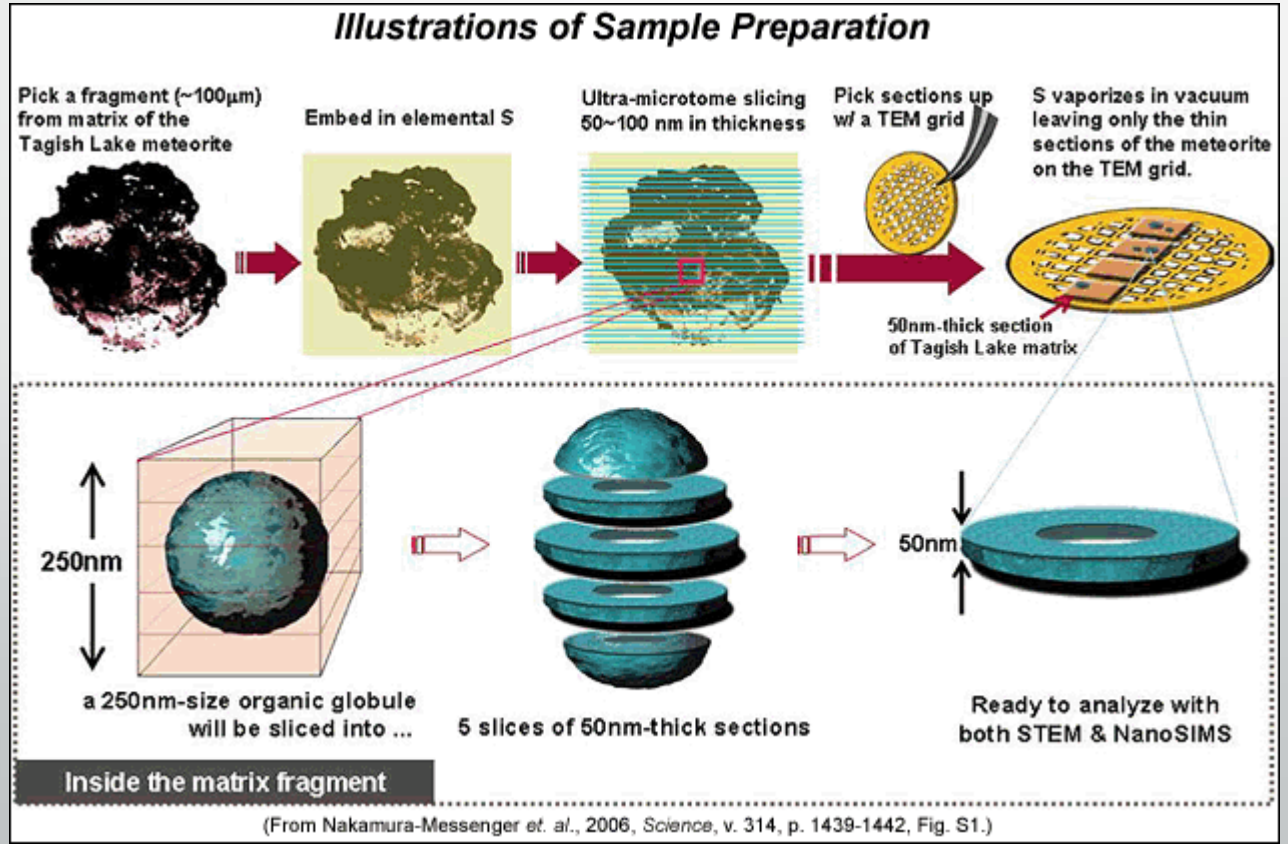
Single crystal silicone diffraction patterns

Advantages over X-ray Crystologrophy

- Small wavelenght allows the analysis of the small crystals and protetin structures.
- More flexibility because we can vary electron acceleration
- No radiation damage
- Electons are charged, therefore more interaction with matter.

Limitations

- Sample has to be very thin (<100nm), so it is electron transperant. Hard to prepare such a sample
- Difraction has to be preformed in vaacum



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Thank you!

Questions?