Micro-texture measurement in SEM-EBSD

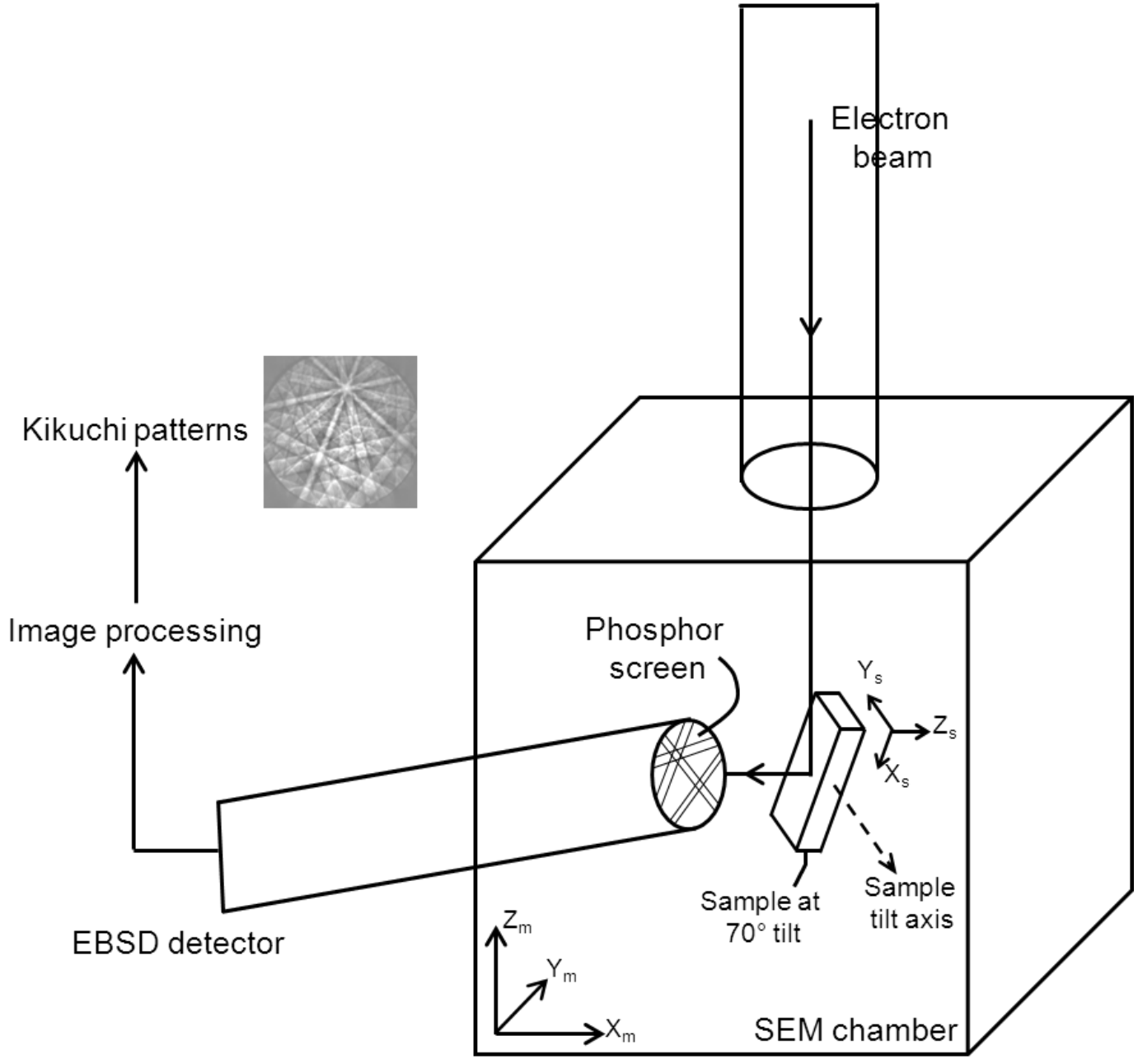
Principle of Pattern formation in EBSD

For EBSD, a beam of electrons is directed at a point of interest on a tilted crystalline sample in SEM

The following steps need to be followed to get the Kikuchi pattern:

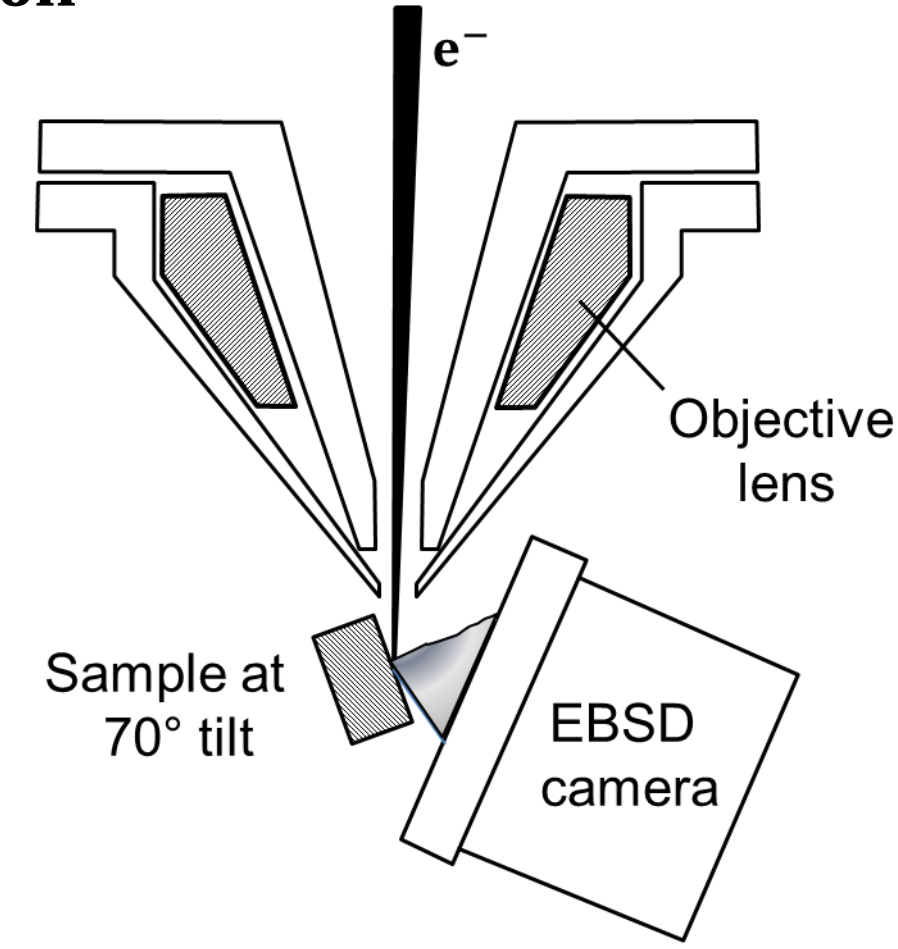
- **Tilt the specimen to get optimum backscattered efficiency**
- **Stop the scanning of surface in SEM to make stationary electron beam**
- **Placement of a recording medium to record the diffracted backscattered electron in SEM**

Schematic of an SEM-EBSD set up



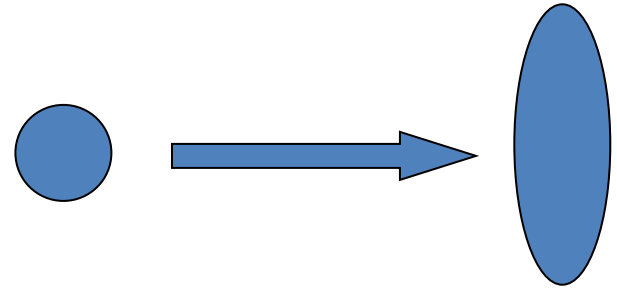
Tilting of sample in SEM for EBSD: It is Critical

It reduces the path length of backscattered electrons escaping from sample after diffraction thus enhance the data resolution



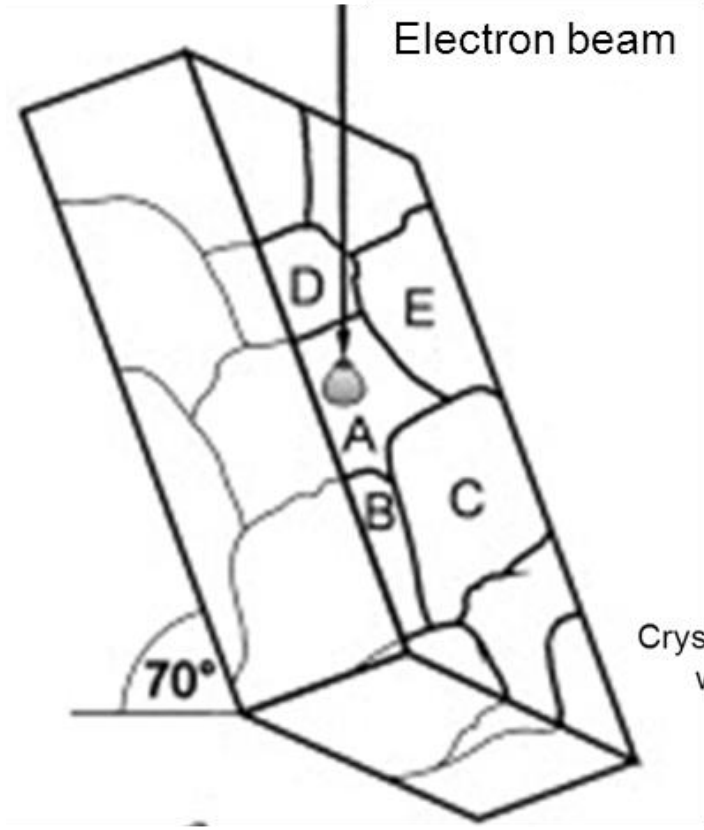
- **The electron/sample interaction volume modifies from pear shape to shallow depth volume**

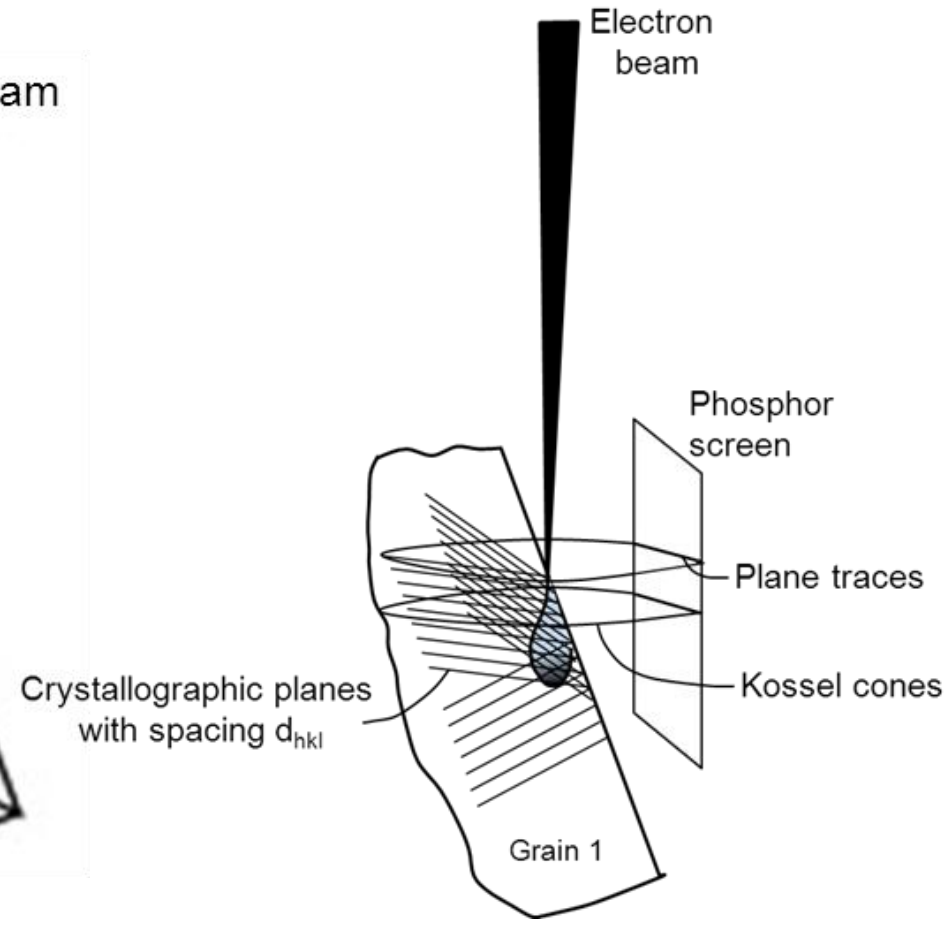
- **The beam circular sizes starts distorting to elliptical with the tilting of the sample thus reduces the resolution**



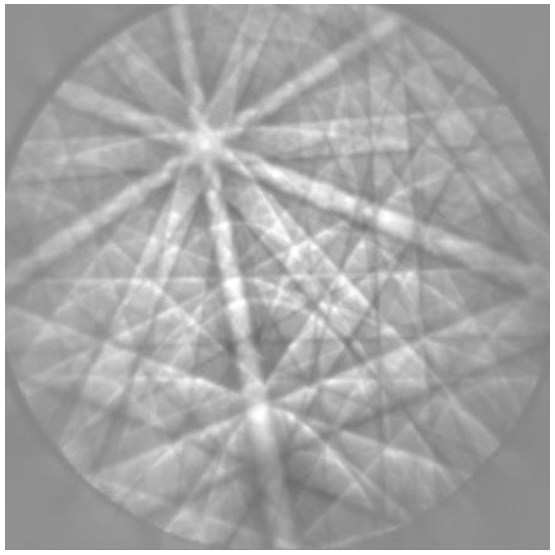
- **Incident beam size : Tilting Increase $\Rightarrow$ Bad resolution**

  Optimum = 70° to the horizontal (Experimental optimization of efficiency and resolution





- **Because the diffraction pattern is bound to the crystal structure of the sample, as the crystal orientation changes the resultant diffraction pattern also changes**



- **Intersections of the Kikuchi bands correspond to the intersection of zone axes in the crystal. These points can be labeled by the crystal direction for the zone axis**

- **The width w of the Kikuchi bands close to the pattern center is given by**

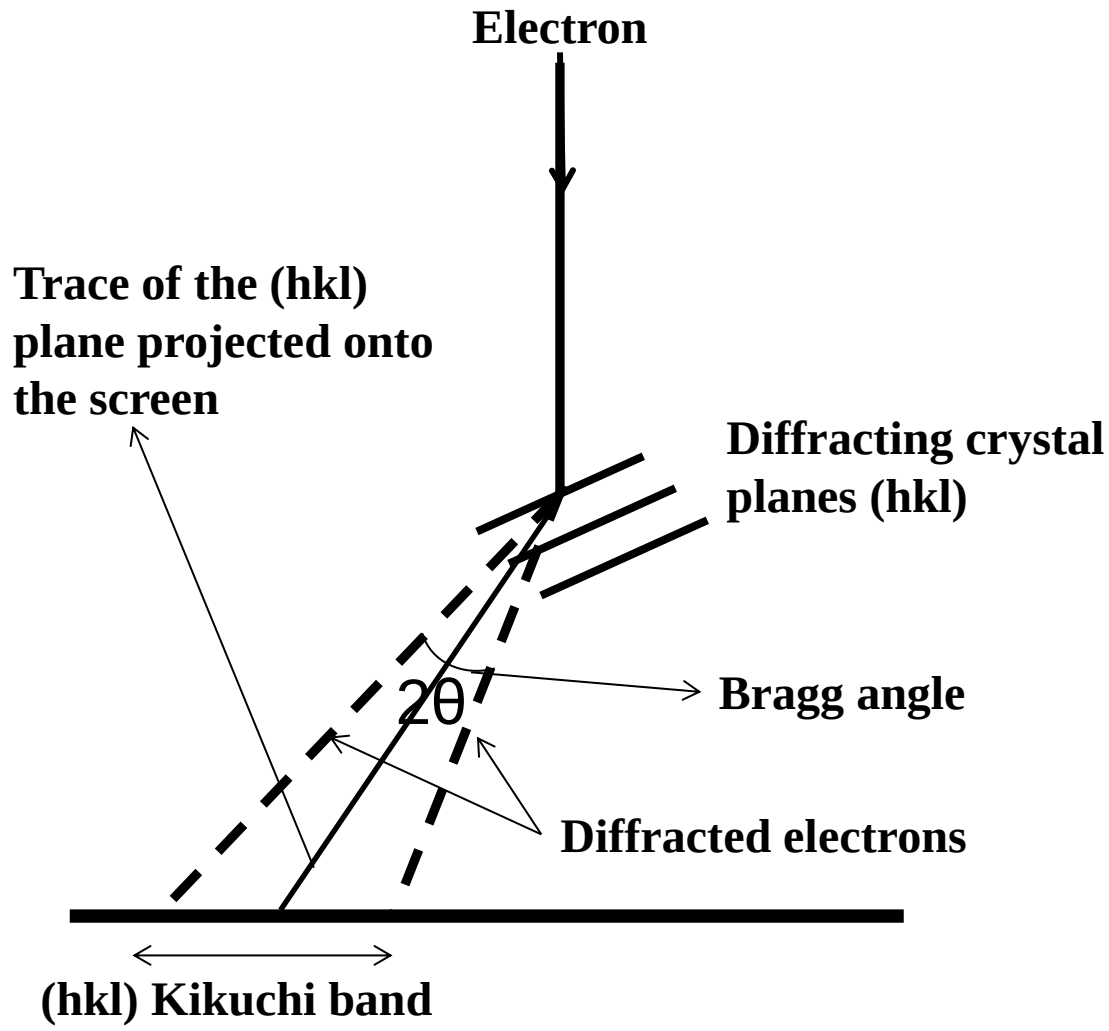
$$w \cong 2l\theta \cong (nl\lambda/d)$$

where, l is the distance from the sample to the screen. Hence, planes with wide d-spacings give thinner Kikuchi bands than narrow planes

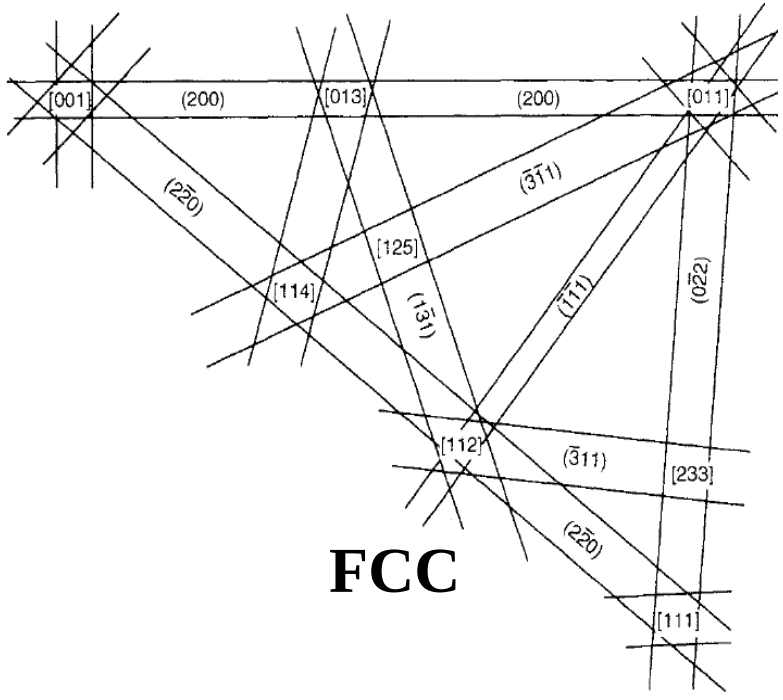
- **Therefore, positions of the Kikuchi bands can be used to calculate the orientation of the diffracting crystal**

Interpretation of EBSD pattern

- The centre lines of the Kikuchi bands correspond to the projection of the diffracting planes on the phosphor screen.
- Each Kikuchi band can be indexed by Miller indices of the diffracting crystal plane which formed it.
- Each point on the phosphor screen corresponds to the intersection of a crystal direction with the screen.



Representation of Kikuchi patterns (one stereographic triangle)



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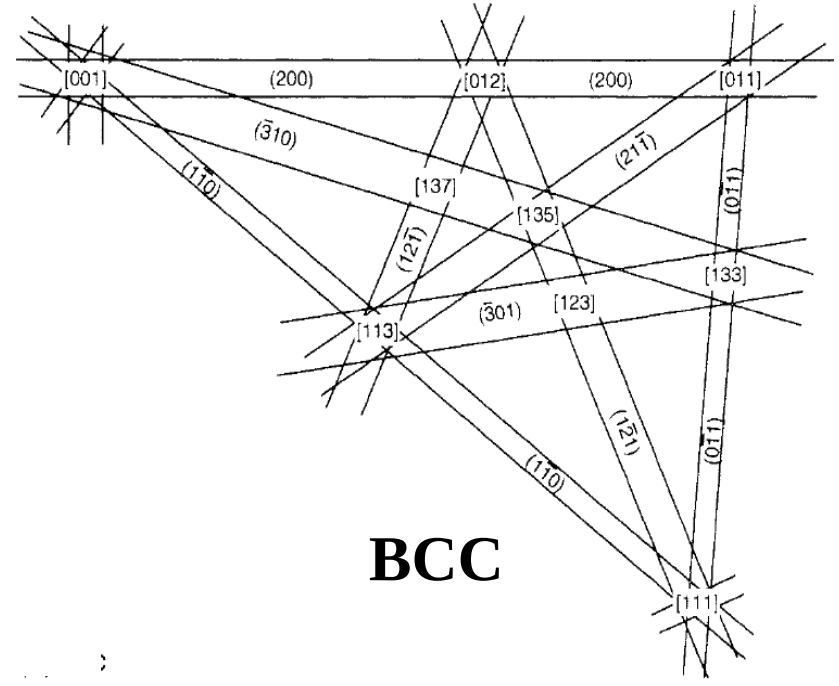
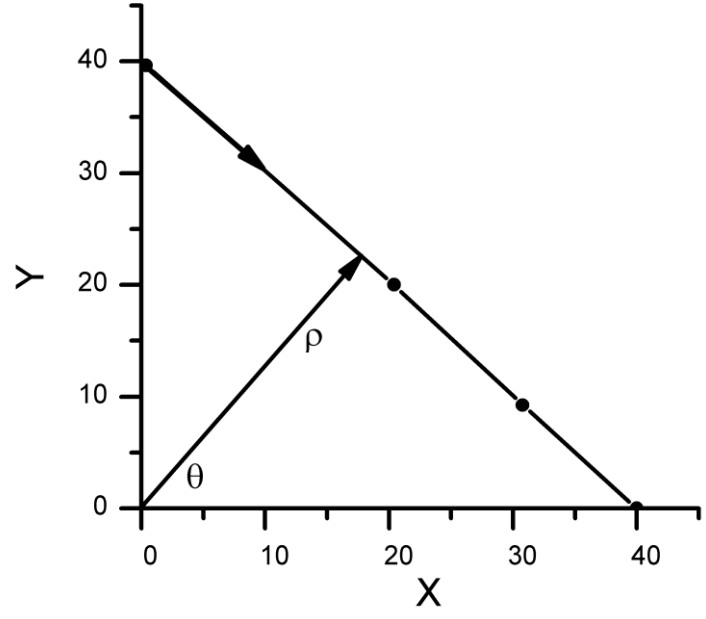


BCC

Automated indexing and orientation measurement

- Crystal orientation is calculated from the Kikuchi band positions by the computer processing the digitized diffraction pattern collected by the CCD camera.

- The Kikuchi band positions are found using the Hough transform. The transform between the coordinates (x,y) of the diffraction pattern and the coordinates (ρ, θ) of Hough space is given by

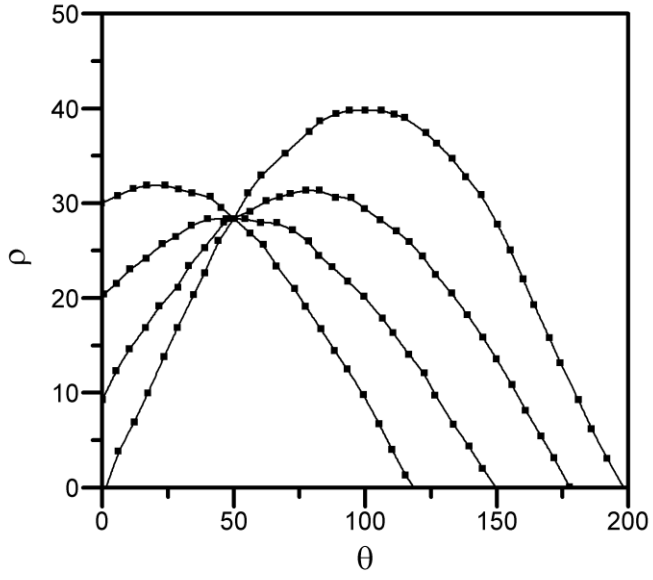


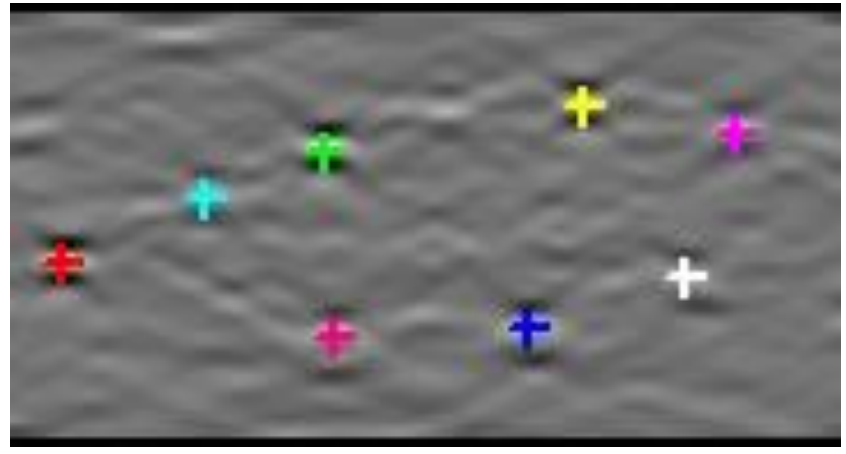
$$\rho = x \cos\theta + y \sin\theta$$

- A straight line is characterized by

(i) the perpendicular distance from the origin (ρ) and (ii) the angle made with the x-axis (θ)

- Therefore a line is represented by a single point (ρ, θ) in Hough space. Kikuchi bands transform to bright regions in Hough space which can be detected and used to calculate the original positions of bands.





- **Using the system calibration, the angles between the planes producing the detected Kikuchi bands can be calculated.**

- **These are compared with a list of inter-planar angles for the analyzed crystal structure to allocate Miller indices to each plane.**

Question

1. What should be the experimental precautions should be taken during EBSD?

2. Explain the tilting of sample in EBSD experiment.

3. What is Hough space?

4. Explain the orientation determination from Kikuchi pattern.

5. How does capturing angle affect in identifying microstructure constituents?