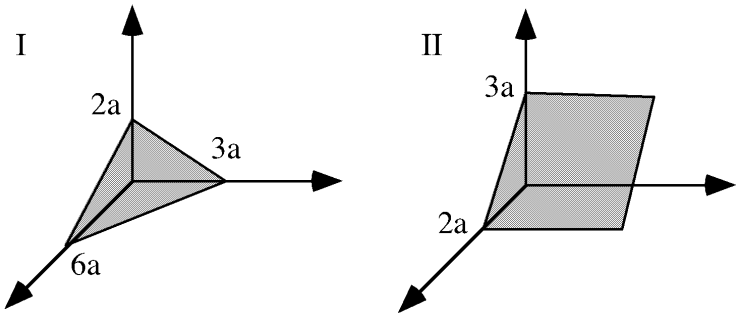
ELEC-3140 Semiconductor physics Oct 5, 2021

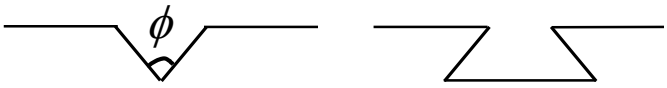
Exercise 2: Crystal directions, reciprocal lattice

1. Let's consider a cubic crystal. a) Draw crystal planes (511), $(23\bar{3})$, (100). b) Define the Miller indices of the crystal planes in figures I and II.



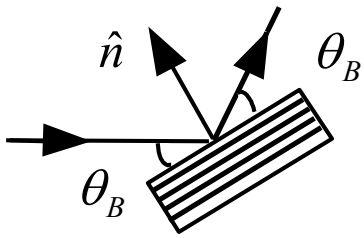
2. a) Calculate the primitive vectors of the reciprocal lattice for the simple hexagonal lattice. b) What has the ratio c/a to be, so that it remains the same also in the reciprocal lattice.

3. A V groove is etched in the direction <011> on the (100) surface of a silicon wafer. The sidewalls of the groove are (111) planes. V groove is formed because the etching speed of the (100) plane is much higher than that of (111) planes. a) What is the angle ϕ at the bottom of the V groove? b) In GaAs wafers, a V groove is formed in the $[01\bar{1}]$ direction but in the direction $[011]$ etching forms a so-called dovetail groove (any idea why?). Calculate the bottom angle of the dovetail groove.



"dovetail"

4. X-ray diffraction is a method used to characterize semiconductors. X-ray ($\lambda_{CuK\alpha_1}$ = 0.15406 nm) in <011> direction hits a single crystalline silicon sample with (100) surface plane and sidewalls in <011> directions. Lattice constant of silicon is 0.54311 nm. The surface normal $\hat{n} = [100]$ and the incident and the diffracted ray lies in the same plane (shown in the figure). Bragg's law is fulfilled in diffraction: $2d\sin\theta_B = \lambda$, where θ_B is the Bragg angle and $d = \dfrac{a_0}{\sqrt{h^2+k^2+l^2}}$ is the distance between successive planes.



a) Calculate the Bragg angle in (400) diffraction.

b) Calculate the angle between the surface and the incident beam in {311} diffraction (in principle, there are 2 possible angles).