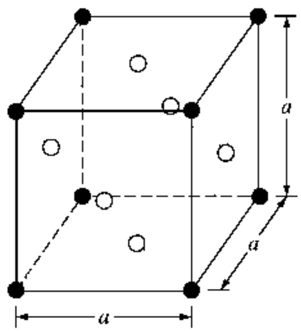
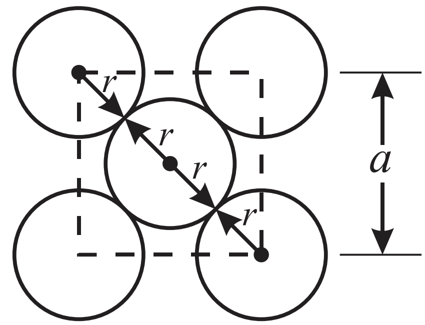
1.21 Consider a face-centered cubic lattice. Assume the atoms are hard spheres with the surfaces of the nearest neighbors touching. Assume the effective radius of the atom is 2.37 Å. (*a*) Determine the volume density of atoms in the crystal. (*b*) Calculate the surface density of atoms in the (110) plane. (*c*) Determine the distance between nearest (110) planes.



fcc cubic lattice in 3D



top view of top face of fcc

From the top view, $r + 2r + r = \sqrt{a^2+a^2} = \sqrt{2}\,a$

$\hookrightarrow a = \frac{4}{\sqrt{2}} r = \frac{4}{\sqrt{2}}(2.37\,\text{Å}) = 6.70337\ \text{Å}$

a) # atoms/unit cell $= 8\text{ corners}\left(\frac{1/8\text{ atom}}{\text{corner}}\right) + 6\text{ faces}\left(\frac{1/2\text{ atom}}{\text{face}}\right)$
$= 4$ atoms

atomic vol. density $= \frac{4\text{ atoms}}{a^3} = \frac{4}{(6.703\times10^{-10})^3}$

$\underline{\underline{\text{atomic vol. density} = 1.328\times10^{28}\ \frac{\text{atoms}}{m^3} = 1.328\times10^{22}\ \frac{\text{atoms}}{cm^3}}}$

b) (110) plane is diagonal side-to-side

atoms $= 4\text{ corners}\left(\frac{1/4\text{ atom}}{\text{corner}}\right) + 2\text{ sides}\left(\frac{1/2\text{ atom}}{\text{side}}\right) = 2$

atomic surf. density $= \frac{2\text{ atoms}}{(\sqrt{2}\,a)\,a} = \frac{2}{\sqrt{2}\,(6.7\times10^{-10})^2}$

$\underline{\underline{\text{atomic surf. density} = 3.147\times10^{18}\ \frac{\text{atoms}}{m^2} = 3.147\times10^{14}\ \frac{\text{atoms}}{cm^2}}}$

c) adjacent (110) planes are spaced by $d/2$ where d is the face diagonal distance

$d_{110} = \frac{\sqrt{a^2+a^2}}{2} = \frac{\sqrt{2}}{2}a = \frac{\sqrt{2}}{2}(6.70337\,\text{Å}) \Rightarrow \underline{\underline{d_{110} = 4.74\ \text{Å}}}$