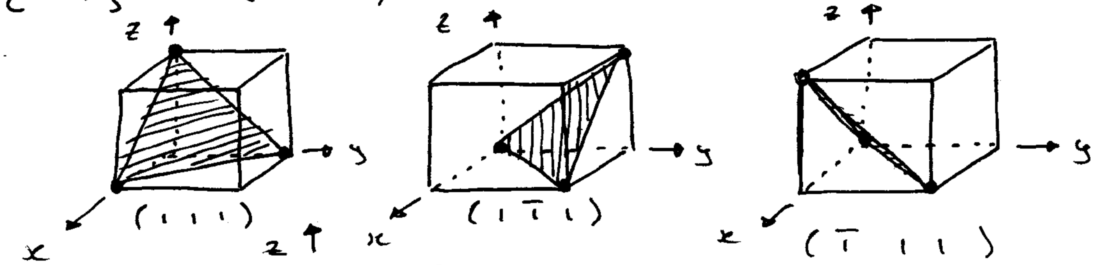
Nov. 12/18
MAT SCI.

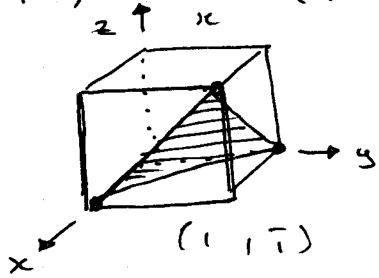
only four are independent
(not parallel)

FCC

$\{111\} \rightarrow$

$(111) \xrightarrow{-1} (\bar{1}\bar{1}\bar{1})$ $\quad (\bar{1}11) \xrightarrow{-1} (1\bar{1}\bar{1})$ $\quad (11\bar{1}) \xrightarrow{-1} (\bar{1}\bar{1}1)$ $\quad (1\bar{1}1) \xrightarrow{-1} (\bar{1}1\bar{1})$





Normal vector to (1 1 1)
is [1 1 1]

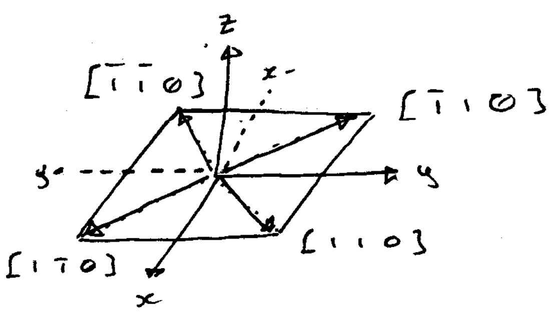
$\langle 1 1 0 \rangle$ $\quad [1\bar{1}0] \xrightarrow{-1} [\bar{1}10] \qquad [110] \xrightarrow{-1} [\bar{1}\bar{1}0]$

$[101]\ [\bar{1}01] \qquad [101]\ [\bar{1}0\bar{1}]$

$[011]\ [0\bar{1}\bar{1}] \qquad [01\bar{1}]\ [0\bar{1}1]$

which one of $[1\bar{1}0]$, $[\bar{1}\bar{1}0]$, $[\bar{1}01]$, $[101]$
$[0\bar{1}\bar{1}]$, $[01\bar{1}]$

are parallel to (111), $(\bar{1}11)$, $(1\bar{1}1)$, $(11\bar{1})$



$V_1 = [u_1, v_1, w_1]$
$V_2 = [u_2, v_2, w_2]$

$$\theta = \cos^{-1}\left[\frac{u_1u_2 + v_1v_2 + w_1w_2}{\sqrt{(u_1^2+v_1^2+w_1^2) + (u_2^2+v_2^2+w_2^2)}}\right]$$

$(111) \xrightarrow[\text{vector}]{\text{Normal}} [111]$

Try $[111]$ and $[1\bar{1}0]$

$$\theta = \cos^{-1}\left[\frac{1 - 1 + 0}{\sqrt{3 \times 2}}\right] = \cos^{-1}(0) = 90$$

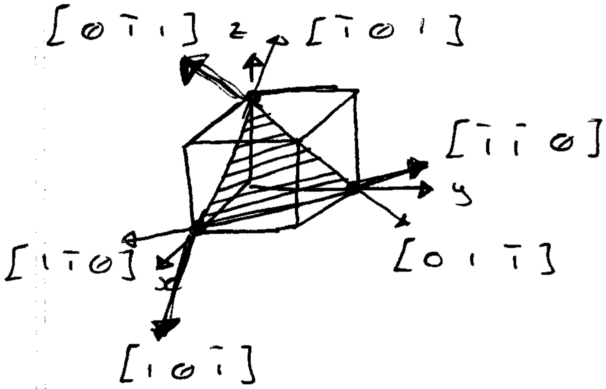
$[1\ 1\ 1]$ and $[0\ 1\ \bar{1}]$

$$\theta = \cos^{-1}\left[\frac{0+1-1}{\sqrt{3\times 2}}\right] = \cos^{-1}(0) = 90$$

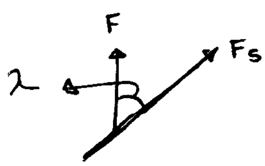
$[1\ 1\ 1]$ and $[\bar{1}\ 0\ 1]$

$$\theta = \cos^{-1}\left[\frac{-1+0+1}{\sqrt{3\times 2}}\right] = \cos^{-1}(0) = 90$$

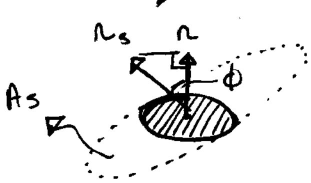
Slip systems on $(1\ 1\ 1)$ are $(1\,1\,1)[\bar{1}\,0\,1]$, $(1\,1\,1)[1\,\bar{1}\,0]$, and $(1\,1\,1)[0\,\bar{1}\,\bar{1}]$.



Slip in Single Crystals $\tau_R = \frac{F_s}{A_s}$



$\cos\lambda = \frac{F_s}{F} \longrightarrow F_s = F\cos\lambda$

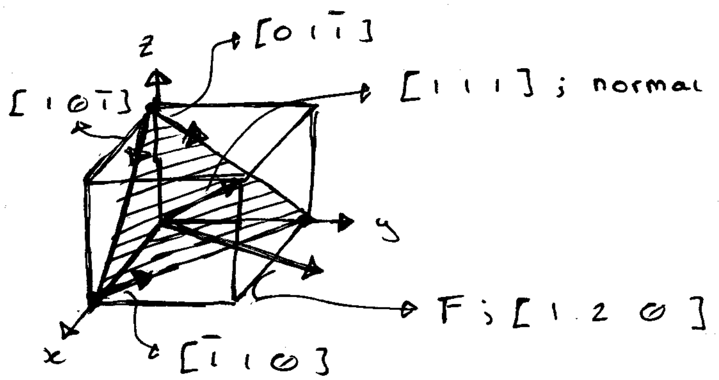


$\cos\phi = \frac{A}{A_s} \longrightarrow A_s = A/\cos\phi$

$$\longrightarrow \tau_R = \frac{F\cos\lambda\cos\phi}{A} \Rightarrow \tau_R = \sigma\cos\lambda\cos\phi$$

Resolved shear stress

Example



ϕ : angle between Force and normal to the surface

λ : angle between Force and slip direction

$\left\{\begin{array}{l}\phi \\ [120] \text{ and } [111]\end{array}\right.$ $\quad \phi = \cos^{-1}\left(\dfrac{1+2+0}{\sqrt{(1^2+2^2)(1^2+1^2+1^2)}}\right) = \cos^{-1}\left(3/\sqrt{15}\right)$

$\left\{\begin{array}{l}\lambda_1 \\ [0 1 \bar{1}][1 2 0]\end{array}\right.$ $\quad \lambda_1 = \cos^{-1}\left(\dfrac{0+2+0}{(1^2+1^2)(1^2+2^2)}\right) = \cos^{-1}\left(2/\sqrt{10}\right)$

$\left\{\begin{array}{l}\lambda_2 \\ [1 0 \bar{1}][1 2 0]\end{array}\right.$ $\quad \lambda_2 = \cos^{-1}\left(\dfrac{1}{\sqrt{10}}\right)$

$\left\{\begin{array}{l}\lambda_3 \\ [\bar{1} 1 0][1 2 0]\end{array}\right.$ $\quad \lambda_3 = \cos^{-1}\left(\dfrac{1}{\sqrt{10}}\right)$

Schmid Factor $\quad$ $\text{Schmid}_1 = \left(3/\sqrt{15}\right)\left(2/\sqrt{10}\right)$

$\text{Sch}_2 = \left(3/\sqrt{15}\right)\left(1/\sqrt{10}\right)$

$\text{Sch}_3 = \left(3/\sqrt{15}\right)\left(1/\sqrt{10}\right)$

$\text{Sch}_1 = 2\,\text{Sch}_2 = 2\,\text{Sch}_3$

$\tau_R = \sigma \cos\phi \cos\lambda = \tau_R = \sigma\,\text{Sch} \rightarrow \tau_{R1} = 2\tau_{R2} = 2\tau_{R3}$

[0 1 $\bar{1}$] is Favored slip direction

Nov. 14/18

$T_s \geq 380$ MPa
% EL $\geq$ 15 %

$\%CW = \frac{d_o^2 - d_d^2}{d_o^2} \times 100 \Rightarrow \frac{10^2 - 7.5^2}{10^2} \times 100\%$

$\%CW = 44\%$

From graph (For brass) : $T_s \doteq 540$ MPa
% EL $\doteq$ 6 %

12 % < % CW < 27 % (From Graph on slide 31)

$\rightarrow 10\,mm \xrightarrow{CW\#1} d_i \xrightarrow{anneal} d_i \xrightarrow{CW\#2} 7.5\,mm$

12 % < % CW #2 < 27 % $\rightarrow$ 20 % as the average

$20 = \frac{d_i^2 - 7.5^2}{d_i^2} \times 100\% \longrightarrow d_i = 8.4\,mm$

The required process

(1) $10 \xrightarrow{\%cw} 8.4\,mm$ $\quad \%CW\#1 = \frac{10^2 - 8.4^2}{10^2} \times 100\% = 29.4\%$

(2) annealing

(3) $8.4 \xrightarrow{cw} 7.5\,mm$ $\quad \%CW\#2 = 20\%$

(minimum number of steps)