Mechanical behavior of materials

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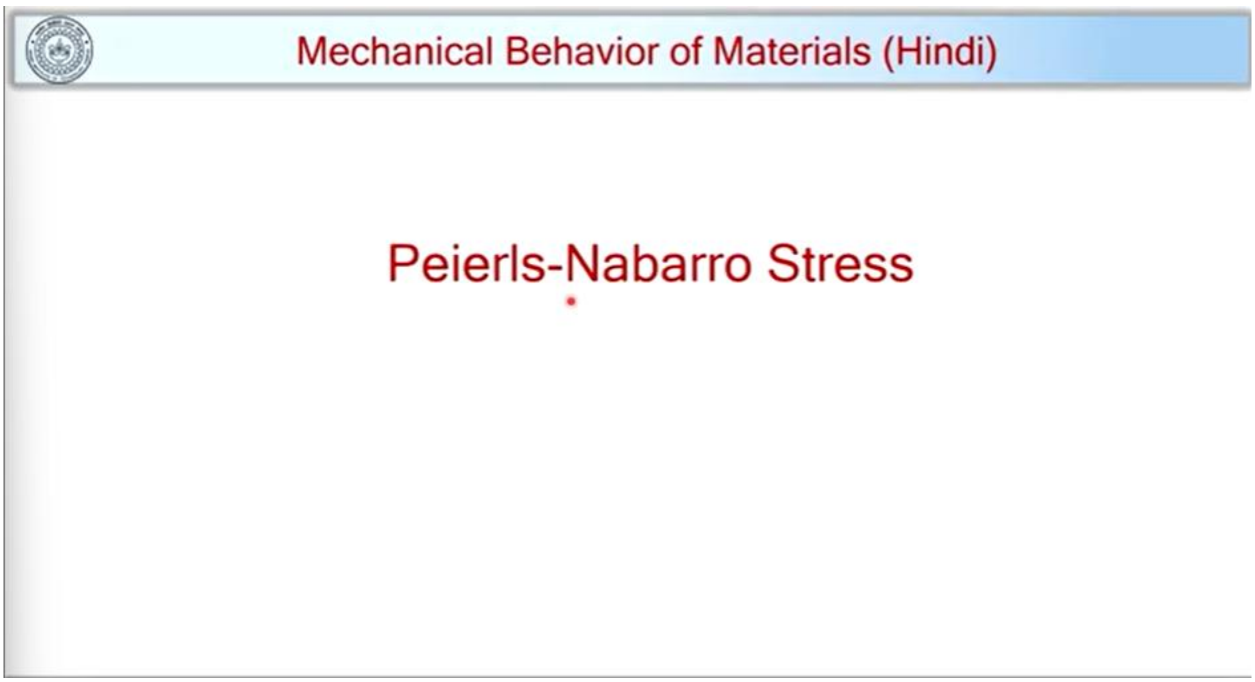
Week-5

Lecture-25

Peierls- Nabarro Stress



Namaskar, ka swagat karta hoon is course mein jiska naam Mechanical Behavior of Materials hai jisko hum Hindi mein padhenge. Last part tak humne dekha tha ki slip ek jo plastic deformation ka mechanism hai woh kaise hota hai. Is part mein hum janenge ki isko hone ke liye kya stress ki avashyakta hai toh uska naam diya gaya hai Peierls-Nabarro Stress.

Toh pehle jante hain humne last time jab dekha tha ki slip jab hoti hai toh humne Tau RSS (τ_{RSS}) yani Resolved Shear Stress ki value nikali thi. Aur jo Resolved Shear Stress ki value humne nikali thi yeh Sigma (σ) jo applied stress hai, $\cos\lambda\cos\phi$, humne dekha tha yeh angles hain aapke plane aur tensile axis ya compressive axis ke beech mein ya direction aur tensile axis aur compression axis ke beech mein. Toh hamare paas ek Tau RSS ki value humne likhi thi σm, m yane m humne kaha tha ek Schmid factor hai, yeh humne dekha tha single crystal ke liye. Yeh resolved shear iski value hai jo humein chahiye jab slip honi ho kisi plane pe.

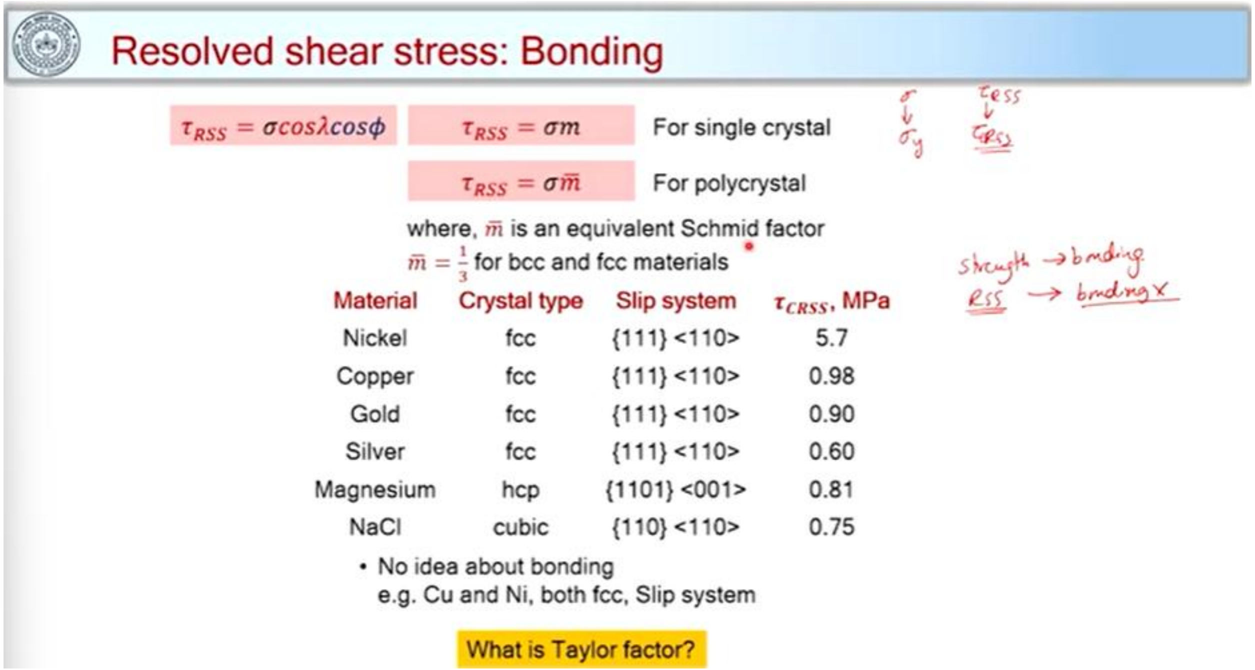
Aur humne single crystal ke liye ek scenario dekha tha. Toh yeh Tau RSS ko main is tarah se likh sakta hoon $\sigma\bar{m}$. Yeh $\bar{m}$ jo hai yeh main polycrystalline material ke liye likh raha hoon kyunki yahan par humne dekha tha single crystal hai aur maine wahan par baat ki thi ki hamare paas koi high angle grain boundaries nahi hain but jo hamare paas polycrystalline material hota hai toh wahan par hamare paas bahut saare grains hote hain. Toh yeh m jo hai woh ek kuch equivalent Schmid factor hai polycrystalline material ke liye jo $\bar{m}$ maine yahan par likha hai aur most of the BCC aur FCC material ke yeh $\bar{m}$, $1/3$ hota hai. Toh yeh Tau RSS ki value main is tarah se likh sakta hoon kuch mere polycrystalline material ke liye.

Aaiye dekhte hain ki yeh Tau CRSS (τ_{CRSS}) jab main baat kar raha hoon jab yielding ke waqt humne yeh baat ki thi, yaad kar lete hum. Toh is tarah se humne baat ki thi jab mera Sigma Y (σ_Y) aata hai uske corresponding jo resolved shear stress hai woh Tau CRSS hona chahiye. Toh humne dekha tha ki Tau CRSS yeh Tau RSS ki value hai at Sigma Y.

Toh yahan par bahut do kuch material humne mark kar liye aur yahan par dekhenge Nickel, Copper, Gold, Silver, Magnesium aur Sodium Chloride. Yahan ke unke crystals type bhi mark kiye hain jaise Nickel, Copper, Gold, Silver mein yeh FCC material hai, Magnesium HCP hai aur Sodium Chloride bhi yeh cubic crystal structure hai aur yahan par slip system bhi mark kiye. Aap yahan par dekhenge ki yeh jo equation hai yeh equation mujhe kuch bonding ke baare mein nahi bata pa raha hai, yani Tau RSS agar main nikalun toh mujhe Sigma Y ek material ka yield strength ki pata hona chahiye. Tau CRSS agar main dekhunga Nickel yahan par slip system kya hai same slip system hai Copper, Gold, Silver kyunki yeh FCC structure hai toh mere slip system same hone chahiye in structures mein par Tau CRSS ki value agar aap dekhenge yahan par Nickel ki sabse zyada hai, Copper 98 hai, Gold ki usse kam hai aur Silver ki usse kam hai. Toh main dekh pa raha hoon ki yeh Tau CRSS ki value mujhe kuch idea nahi de rahi ki meri kaun si slip system active rahegi ya mera material ka strength kis par depend karega. Toh Tau CRSS mujhe koi idea nahi deta ki mera material ka bonding ya bonding nature kya hai. Toh humein aur kuch naya criteria naya parameter dhoondhna padega jiske wajah se main bata paunga ki material ki strength mere material ke bonding par kaise depend karti hai.

Toh humein dekhna hai ki material ki jo strength hai woh bonding ke saath kaise related hai yeh humein dekhna hai aur humne dekha tha ki yeh resolved shear stress is point se hum dekh pa rahe ki resolved shear stress mujhe bonding ka koi gyan nahi kara pa raha hai. Toh ab hum jante hain dekhte hain isko hum kis tarah se connect kar sakte hain bonding ke saath yani strength ko bonding ke saath kis tarah se connect karenge. Toh yeh point maine yahan par mention kiya hai ki humein koi bhi idea nahi milti jab main Tau CRSS ki baat kar raha hoon bonding ke baare mein. Toh yani simplify is tarah se likh sakta hoon main Copper aur Nickel dono FCC hai dono ki slip system same hai par dono mein Tau CRSS ki value different hai abhi humein janna hai ki kyun hai.

Toh iske pehle main abhi maine yahan par ek baat ki thi ki $\bar{m}$ jo hai jo equivalent Schmid factor hai yeh humne baat ki thi polycrystalline material ke liye. Main aapko ek exercise dena chahta hoon ki aapko dhoondhna hai ki Taylor Factor kya hota hai material ka polycrystalline material mein Taylor Factor kya hota hai aapko dhoondhna hai.



Chalte dekhte hain ki jab mera dislocation move hota hai toh usko kitna stress lagta hai. Toh yeh jo Peierls-Nabarro stress hai yeh wahi stress quantify karta hai ki dislocation movement ke liye kitna stress required hoga. Toh agar mere paas yeh dislocation hai yahan par maine is dislocation mark kiya hai aur yeh dislocation yahan se move hoga toh yeh slip plane par move hoga yeh. Toh yeh jo dislocation movement ke liye mujhe kitna stress lagega shear stress lagega yeh hum mujhe dhoondhna hai. Toh yeh mujhe milta hai Peierls-Nabarro stress se. Toh yeh jo stress rahega yeh depend karega mera inter-atomic bonding par kyunki humne jab baat ki thi jab dislocation move hota hai toh maine humne baat ki thi ki yeh yahan par making aur breaking of bonds hote hain yani bonds bante hain toot-te hain bante toot-te us tarah se dislocation ka movement hota hai. Toh jab stress ki jab main baat karunga ya bond banane aur todne ke liye jo mujhe stress ya energy chahiye woh depend karegi mere inter-atomic bonding pe.

Toh Peierls-Nabarro stress ya Peierls stress aisa bhi kaha jata hai literature mein. Toh yeh kuch is tarah se likha jata hai, yeh mera shear stress hai aur yeh suffix Peierls-Nabarro stress ya kabhi-kabhi is tarah se bhi likha jata hai Tau PN (τ_{PN}) bhi likhte hain. Toh yeh ek hi cheez darshata hai. Toh yeh Tau PN jo hai is tarah se likha jata hai: $\tau_{PN} = \frac{2G}{1-\nu} e^{-\frac{2\pi w}{b}}$ Yeh hum janenge jo G hai yeh mera Shear Modulus hai material ka aur yeh jo w hai yeh mera width of dislocation hai. Humne last class mein dekha tha ki yeh width of dislocation kis tarah se define karte hain aur iska ek formula diya hai yahan pe, yeh width of dislocation is tarah se likh sakte hain: $w = \frac{d}{1-\nu}$ Yeh d jo hai yeh inter-planar distance hai aur inter-planar distance yahan pe hum dekhenge agar yeh main do plane maan chal raha hoon ki yeh glide ho raha hai ek dusre ke upar ya slip ho raha hai ek dusre ke upar yeh jo inke beech ka jo distance hai yeh mera d hai, yeh inter-planar distance hai. Aur ν mera hai Poisson's ratio, yeh humne dekha tha ki Poisson's ratio kya hota hai. Toh yeh formula hai, yeh formula iska derivation is course ke scope ke bahar hai toh hum isko nahi dekhenge par aapko aur kuch information chahiye is formula ke baare mein toh aap ek accha paper dekh sakte hain "50 Years of Peierls-Nabarro Stress". Toh yeh paper aap dekhiye yahan pe ek 50 saal jo hue the Peierls-Nabarro stress ko 1997 mein toh wahan par dekh aap dekhenge is paper mein ki bahut saare mathematical relations dekhenge iska modification bhi dekhenge is equation ka. Yeh simplest form hai Peierls-Nabarro stress ka.

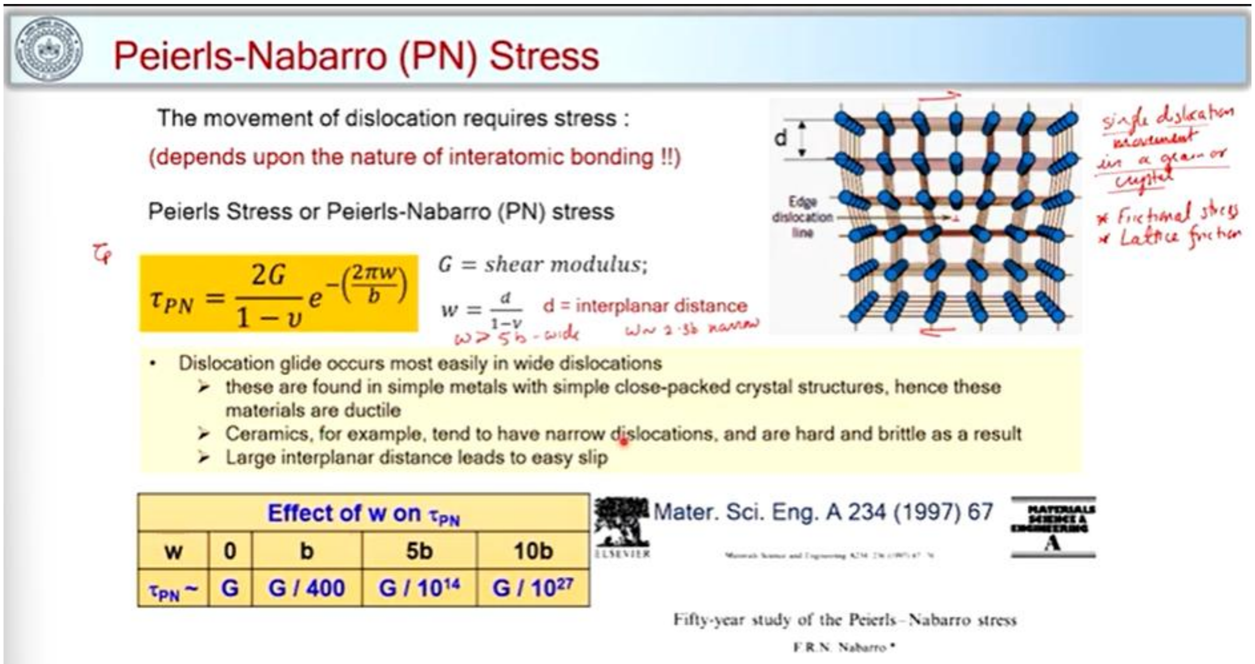
Toh abhi hum jante hain ki iska implication kya hai hamare course ke liye. Hamare paas ek shear stress mil raha hai aur shear stress kis pe dependent hai mere shear modulus par dependent hai, mere Poisson's ratio par dependent hai aur yeh jo exponential jo term hai yahan par width of dislocation par depend hai aur yeh Burgers vector b yahan par Burgers vector par bhi dependent hai aur width kis par dependent hai yeh meri dependent hai inter-planar spacing aur distance aur Poisson's ratio pe.

Toh jante hain meri width of dislocation humne baat ki thi. Toh agar last class mein uska revision kar lete hain width hum is tarah se baat kar sakte hain width humne baat ki thi greater than $5b$ hai toh yeh wide dislocation kaha tha aur width close to 2 to 3 b hai toh yeh narrow dislocation humne kaha tha. Toh yahan par dekhte hain maine width yahan par kuch values hain width ki yeh mark ki hai $0b$, $5b$ aur $10b$ aur iske corresponding shear stress ki value kya aayegi. Toh agar main dekhunga b ki value agar main zero put kar raha hoon yahan par toh e^0 aayega 1 aur yeh jo value hai $2G$ aayegi, $2G/(1-\nu)$ aayegi. Agar ν 0.3 hai toh $2G/0.7$ yani close to $2G$ aayega ya G ispe mark karunga toh yani yeh jo shear stress hai yeh G rahega par jaise meri b badh rahi hai yahan pe yane small increment hi ho raha hai b se $5b$ ho raha hai $5b$ se $10b$ ho raha hai toh aap dekhenge ki jo shear stress ki value hai yani Peierls-Nabarro stress ki value hai woh drastically decrease ho rahi hai. Toh aap dekhenge ki $G/1000$ ho gayi hai $5b$ ke liye toh $G/10^{14}$ yani bahut kam ho ja rahi hai. Toh aap dekhenge ki mera width of dislocation bahut important role play karta hai Peierls-Nabarro stress ke liye.

Peierls-Nabarro stress kya hai? Jo stress require hai mere ek dislocation ko move karne mein aur kisme move karne mein? Ek single crystal mein ek grain ke andar move karne mein jo stress lagega woh mera rahega Peierls-Nabarro stress. Toh isko main yahan pe main likh leta hoon ki yeh jo hai ek dislocation ko single dislocation ko move karne ke liye, ek single dislocation ko move karne ke liye in grain aur crystal. Toh mera ek jab single dislocation rahega crystal ke andar ya ek dislocation rahega aur usko move karne ke liye jo stress lagega woh hai mera Peierls-Nabarro stress. Isko kabhi-kabhi literature mein is tarah se bhi likhte hain isko Frictional Stress bhi likhte hain, Frictional Stress bhi likhte hain ya kabhi Lattice Friction bhi likhte hain. Toh aapko yeh terms yaad rakhne hain.

Abhi jante hain iske baare mein aur. Toh kuch points is equation se hum is tarah se likh sakte hain ki jab mera dislocation glide, glide yani slip ya movement hai ek kisi slip plane pe usko main kehta hoon dislocation glide easily hoga kis kis par? Wide dislocation par humne dekha tha ki $5b$ ke agar upar hai toh jo shear stress ki value hai ghat rahi hai yani mujhe kam stress lagega dislocation ko move hone mein. Toh wide dislocation jo hai mere easily move ho sakte hain aur yeh jo wide dislocations hain yeh humein milte hain close packed crystal structures mein isliye jo close packed crystal structures hain yeh ductile hote hain. Toh humne baat ki thi slip jab hum baat kar rahe the tab humne baat ki thi ki slip jo hoti hai woh close packed plane aur close packed directions mein hoti hai. Toh yahi ek iska reason hai ki close packed plane aur close packed direction pe kyun honi chahiye kyunki wahan pe jo stress lagega mera dislocation ko move karne mein woh kam rahega isliye close packed plane aur close packed direction hi choose karte hain aur wahan pe mere jo dislocations hain woh wide dislocations rahenge. Agar hum doosre material kuch dekhte hain ceramics ya jahan pe bonding ionic hai ya covalent hai toh wahan pe aap dekhenge ki mujhe jo dislocations milte hain woh narrow dislocations hain. Narrow dislocation yani humne vyakhya ki thi yeh 2 to 3 b hai aur yeh isiliye hard hote hain ya brittle hote hain.

Aur yeh bhi ek point hai Large Inter-planar Distance jo jab rahega tab easy slip hogi. Toh agar yeh d zyada rahega agar hum yahan pe dekhenge d agar d ki value yahan pe increase hogi toh w ki value increase hogi aur w ki value increase hogi toh yeh shear stress ghatega. Isko aur acche se dekhte hain agli slide mein.



Toh abhi dekhte hain ki Burgers vector ka kya role hai. Humne Burgers vector bhi dekha tha is equation mein yahan pe mera Burgers vector hai. Aap dekhenge ki ek exponential term mein Burgers vector hai denominator mein hai toh aur width of dislocation maine baat ki thi yeh $d/(1-\nu)$ aur jab hum baat karenge mera d ab jab badhega tab aap dekhenge kyunki w yahan pe hai aur main is tarah se likh sakta hoon ki jo width of dislocation directly proportional rahega d se is relation ke wajah se aur yeh w hai yeh numerator mein hai aur yahan par negative sign hai toh aap dekhenge ki jab mera d badhega tab yeh jo Tau PN hai yeh value ghatega. Toh aap dekhenge ki jaise jaise hamara d badhega ya d yani inter-planar spacing badhega waise waise hamara shear stress jo lagega woh ghatega. Usi tarah se b mera denominator mein aur b ki value jaise ghategi waise hi Tau PN ki value bhi ghategi. Toh b yeh mera Burgers vector hai. Aap dekhenge ki yeh do points mein is tarah se likh sakta hoon ki d kiske liye badhta hai? d aap janenge ki close packed planes jo hote hain woh widely spaced hote hain, widely spaced yani unke beech ka jo distance hota hai woh hamesha zyada hota hai as compared to other planes toh isliye close packed planes mein jo shear stress lagega woh kam rahe aur b shortest kab rahega yani b yani Burgers vector kam kab rahega jab yeh close packed direction mein hum baat karenge tab tab b ki value sabse kam rahegi.

Toh d ka bhi ek simple cubic ke liye hum relation dekh lete hain: $d = \frac{a}{\sqrt{h^2+k^2+l^2}}$ Yeh mere Miller indices se mere planes ke h, k, l aur a jo hai yeh mera lattice parameter hai agar cubic ke liye maan ke chal raha hoon yahan pe main likh leta hoon yeh cubic ke liye valid hai. Toh yeh d hai inter-planar spacing. Toh aap dekhenge jab yeh close packed plane jaise $\{111\}$ plane hai FCC mein agar aap d nikalenge toh sabse widely spaced honge.

Toh dekhte hain kuch ek conclusion in do points se toh isliye jo slip hoga material mein metals mein ya alloys mein aap dekhenge ki yeh hamesha hoga close packed planes aur close packed direction ke around.

Toh FCC mein abhi dekhte hain ek example lekar dekhte hain. Toh main humne dekha tha FCC kya hota hai yani mere atom se corners par aur kuch atoms hai mere face centers pe. Toh yeh ho gaya mera FCC structure aur isme agar hum dekho hum dekhenge toh jo shortest lattice translation vector hai yeh mera yeh direction hai. Toh lattice translation kya hota hai abhi abhi aap dekhenge ki mere paas lattice points kahan pe hai lattice points hai mere corners pe aur face centers par. Toh koi bhi lattice point ka distance doosre lattice point se isko kehte hain hum lattice translation yani yeh ek lattice point hai aur yeh doosra lattice point hai toh yahan ka distance hoga ek lattice translation. Yeh ek lattice point hai yeh ek lattice point hai iska jo distance hoga yeh lattice translation kaha jayega par shortest kaun sa hoga yahan par aap dekhenge shortest mera yeh direction hai jo $1/2[110]$ ke around hai yani aap dekhenge corner se face center tak ya is direction ke around jo lattice translation ho rahi hai woh sabse shortest hai sabse chhoti hai isko hum lattice translation kehte hain aur isi ko hi hum jab dekhenge isi ko hum kehte hain Burgers vector. Yeh hogi meri $a/2 < 110 >$ agar mera crystal hai FCC aur jo sabse shortest lattice translation vector jo hoga wahi mera Burgers vector ki value rahegi wahi meri Burgers vector ki magnitude rahegi.

Usi tarah se agar main BCC dekhta hoon BCC crystal structure mein agar main atoms mere body center pe rehte hain yahan pe aap dekhenge ki ek corner se doosre corner point tak ya main dekhunga ki yeh point se yani corner point se body center tak yeh ek mera lattice translation vector hai. Toh yahan par shortest lattice translation vector kaun sa hai aap dekhenge yahan par shortest lattice translation vector hai $a/2 < 111 >$ aur aap yeh bhi dekhenge ki yeh jo $< 111 >$ direction hai BCC mein yeh close packed direction hai. Usi tarah se aap dekhenge ki yeh jo direction hai FCC mein $< 110 >$ direction yeh close packed direction hai. Toh aapka shortest lattice translation vector BCC ke case mein hoga $a/2 < 111 >$ aur b ki value yahan par main consider karunga yeh Burgers vector ho jayega hamara BCC mein iski value aa jayegi $a/2 < 111 >$, $1/2 < 111 >$ ki around.

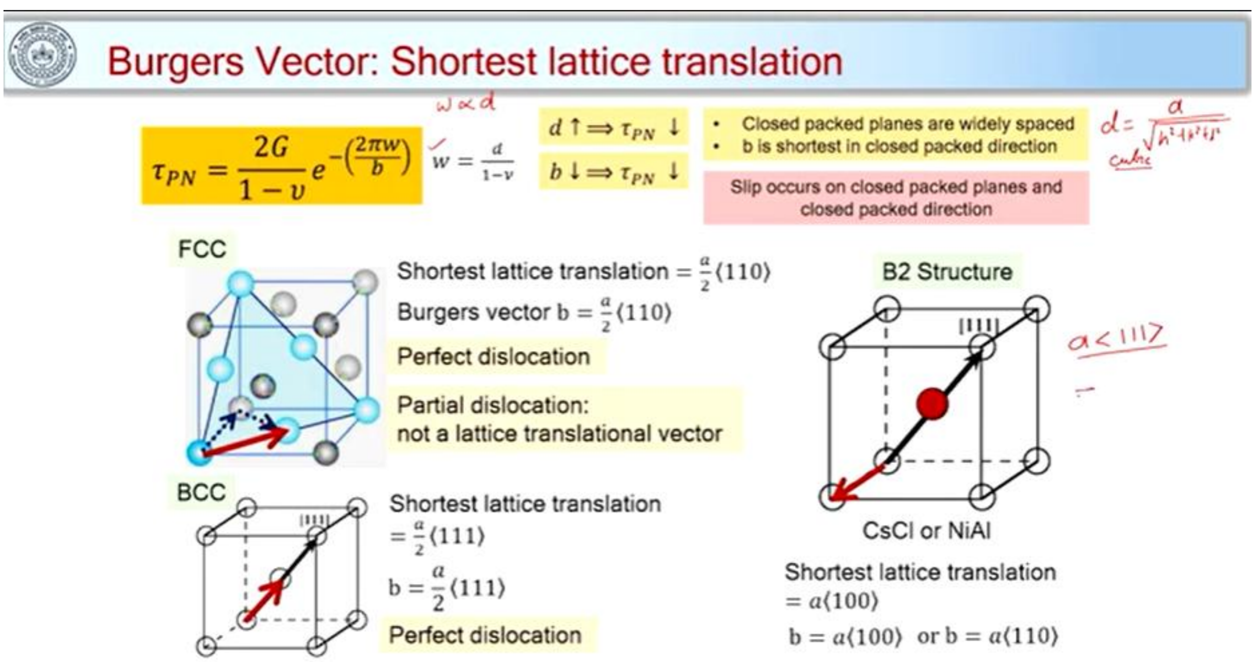
Abhi main B2 structure consider karta hoon toh B2 structure mein yeh lag toh BCC ki tarah hai par yeh BCC structure nahi hai kyunki yahan par aap dekhenge yeh jo center atom hai body centered atom hai yeh doosre material se ya doosre element se bana hota hai. Toh jaise main agar $CsCl$ ya $NiAl$ structure lunga toh aap dekhenge ki Aluminum mera corners par rahega aur Nickel mera body center par rahega. Toh agar is case mein agar hum dekhenge ki lattice translation kahan pe toh mera lattice translation humne dekha tha ki ek lattice point se doosre lattice point pe par is case mein hum consider karenge jab B2 structure consider karenge toh mera lattice translation hoga is point se is point tak yani ek corner atom se is corner atom tak yani yeh diagonal ke around is tarah se hoga na ki yahan pe $1/2 < 111 >$ yeh mera lattice translation vector nahi hoga kyunki aap dekhenge ki yeh jo lattice point hai yeh kisi aur material se ya kisi aur element se bana hua hai aur body center jo atom hai woh kisi aur element ka hai. Toh isliye yeh $1/2 < 111 >$ mera lattice translation nahi hoga is case mein lattice translation ho gaye mere yani lattice translation jab baat karunga toh same element ke points ke around hi main lattice translation consider karunga. Toh is case yeh mera lattice translation ho sakta hai toh yeh ho jayega mera $a < 100 >$ is direction mein ya jo mera Burgers vector hai yeh ho jayega $a < 100 >$ ya kabhi-kabhi kisi is structures mein $a <$

$110 >$ bhi mera lattice translation ho sakta hai aur main dekhunga agar lattice translation yahan pe consider karunga toh agar close packed direction consider karna hai toh mera $a < 100 >$ hoga yeh mera lattice translation hoga.

Toh yeh ho gaye mere yeh jo Burgers vector yahan par maine mark kiye yani ek lattice point se doosre lattice point tak isko kehte hain Perfect Dislocations. Toh abhi ek kuch concept yani yeh dislocation jo mark karunga jo agar main dislocations ki baat karunga aur lattice displacements ki baat karunga agar lattice displacements ka magnitude mere shortest lattice translation vector se bhi chhota hai toh usko main kehta hoon Partial Dislocations. Jaise hum dekhenge ki yeh jo perfect dislocation hai yeh split hota hai yeh split hota hai do dislocation mein aur aap dekhenge ki is tarah se split hota hai kuch aur yeh jab split hota hai toh aap dekhenge yeh jo point hai yahan par koi lattice point nahi hai toh par yeh jo dislocation hai jo blue mein maine mark kiye in dislocations ko main kehta hoon Partial Dislocations kyunki yeh lattice translation vectors nahi hai yahan pe kyunki yahan pe koi lattice point nahi tha yahan pe. Toh isliye inko kehte hain Partial Dislocations.

Toh yeh ho gaya mera Burgers vector ka kuch notation jab hum baat karenge dislocation ke baare mein perfect ya partial dislocation.

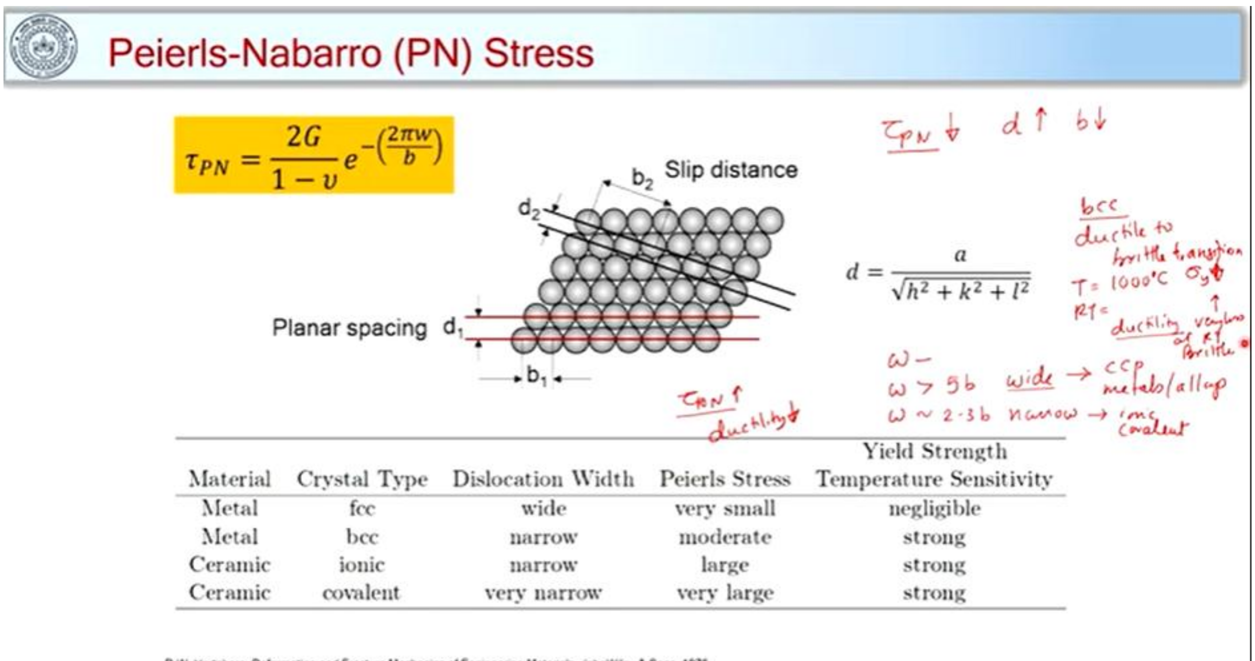
Abhi hum aate phir se hamare Peierls-Nabarro stress ke liye. Humne isliye discuss kiya tha ki hum yahan par Burgers vector ki value agar ghategi tab hum baat karenge ki Peierls-Nabarro ki stress ki value bhi ghat-ti hai. Toh ab dekhenge ki jaise BCC aur B2 structure ki baat karte yahan par dekhenge ki yahan par agar mera yeh jo Burgers vector hai yahan par BCC ke case mein $1/2 < 111 >$ hai aur B2 ke case mein aap dekhenge ki agar yeh agar main Burgers vector consider kar raha hoon $a < 100 >$ toh iski value badh gayi hai. Iski value badhegi toh aap dekhenge ki Peierls-Nabarro stress jo hai is structure mein zyada hona chahiye. Toh main kuch is tarah se likh sakta hoon Peierls-Nabarro stress B2 ke case mein BCC se zyada hoga kyunki aap dekhenge ki jo Burgers vector ki value hai woh badh gayi hai.



Peierls-Nabarro stress ke baare mein aur jante hain. Yeh mera equation hai Peierls-Nabarro stress ka aur kuch lattice hum yahan par consider karenge yahan par main close packed structure consider kar raha hoon. Abhi humein kuch planes consider karunga is close packed structure mein. Toh yeh plane consider karunga maan lete hain is plane par mera slip ho raha hai aur yeh jo planes hain do planes hain iske beech ka jo distance hai isko main d_2 maan raha hoon aur mera jo repeat distance hai repeat distance ko bhi main Burgers ya slip distance keh sakta hoon ya Burgers vector yahan pe b_2 maan raha hoon. Aap dekhenge ki yeh mera atom tha aur is plane pe jab main baat karunga toh yeh yahan pe aa raha hai. Toh yahan se yahan tak ka distance jo hoga yeh mera slip distance hoga isko main Burgers vector manunga. Aur ek plane consider karte hain jiski planar spacing main d_1 maan raha hoon toh aap dekhenge yeh jo plane hai yahan pe repeat distance kya hai ya slip distance kya hai yeh mera slip distance hoga kyunki yahan par center hai is plane atom ka aur yeh jo doosra atom hai yahan par iska ek center hai toh dono ke beech ka jo distance hoga yeh mera b_1 hoga. Toh aap dekh payenge ki mera b_1 jo hai yeh case mein yeh d_1 ke case mein yeh chhota hai compared to b_2. Toh aap dekhenge ki yahan par jo shear stress lagega yani yahan par jo slip hona chahiye woh aasaan hoga is case ke. So aap dekhenge ki jo main d ki value bhi nikal raha hoon toh d ki value jo hai $a/\sqrt{h^2+k^2+l^2}$ yeh humne dekha tha. Toh yeh cubic system ke liye toh yahan par aap dekhenge ki yeh jo d_2 hai yeh yeh jo planes hain yeh close packed planes nahi hain kyunki yahan par jo direction maine mark ki b_2 hai yeh close packed direction nahi hai yahan pe. Toh aap dekhenge ki yeh jo agar yeh plane close packed nahi hai toh inka jo distance hai woh chhota rahega kam rahega compared to close packed planes se. Yeh jo agar arrangement main dekh raha hoon red wali isme mere jo planes hain atom se exactly close packed hain toh aap dekhenge ki yeh jo d_1 hai yeh d_2 se zyada rahega bada rahega aur b_1 hai yeh chhota rahega. Toh humein agar yani Tau PN pe agar hum effect dekhenge toh agar mera d badh raha hai aur b ghat raha hai toh Tau PN jo hai woh ghatega. Toh yeh ek effect hai d aur b ka. Toh ab dekhenge is case mein mera yeh plane prefer hoga slip ke liye kyunki yahan par jo Tau PN aayega woh kam aayega is case ke comparison mein.

Abhi humne do cheez baat ki thi last class mein aur abhi bhi humne width of dislocation ki baat ki thi. Toh humne width of dislocation ki baat ki thi tab humne bataya tha ki agar width $5b$ se greater hai toh hum isko kehte hain wide dislocation aur yeh wide dislocation humne dekha tha yeh milte hain hamare close packed structures mein metals mein alloys mein aur yeh jo w close to 2 to 3 b hai yeh milte inko kehte narrow dislocation. Narrow dislocation width hai isme yeh humein ionic ya covalent bonded materials mein milte hain. Toh hum dekhenge yahan par kuch material humne mark kiye metals mein mark kiye FCC structure hai BCC structure hai aur ceramics mein maine mark kiye ionic aur covalent bonded materials hain. Toh hum yahan par dislocation width ki hum baat kar rahe toh jahan par dislocation width wide hai maine kaha tha FCC mein dislocation width wide milti hai aur BCC mein dislocation width narrow hai. Toh aap dekhenge ki Peierls stress ki jo value hai toh yahan par Peierls stress ki value very small hai ya kam hai FCC ke case mein aur BCC ke case mein moderate hai. Toh aap dekhenge ki jo bhi FCC material hote hain woh as compared to BCC material ductile hote hain yeh iska reason hai aap Peierls-Nabarro stress se isko explain kar sakte hain. Aur agar hum dekhenge ceramics ke case mein jo dislocation width hai woh narrow hai aur kuch ceramics ke case mein agar woh zyada hi narrow hai aur chhoti hai isse bhi chhoti hai toh aapko milega ki Peierls stress bahut zyada rahega. Bahut zyada Peierls stress yaane dikhayega ki aapka strength zyada hai par woh jo material se woh strength jo hai yani Peierls-Nabarro stress increase hoga increase hoga yani jo material se woh ductility uski ghategi. Toh yeh ek relation aapko yaad rakhna hai.

Toh aur ek kuch points hai yahan pe Yield Strength ka Temperature ke saath sensitivity. Toh jahan par aap dekhenge ki width of dislocation narrow hote ja rahi uska temperature dependence yani strength ka temperature dependence badhte jata hai. Jaise agar aap dekhenge ki agar BCC material se toh woh dikhate mere ductile to brittle transition yani kya hota hai isko likh lete Ductile to Brittle Transition Temperature dikhata hai yeh. Toh iska matlab yeh hota hai ki agar main BCC ko consider kar raha hoon kisi high temperature par maan lete hain 1000 degree par agar main deform kar raha hoon aur room temperature par aakar deform kar raha toh aap dekhenge ki BCC ki strength jo hai Sigma jo hai Sigma Y woh bahut ghategi high temperature par aur room temperature par woh badhegi aur aap dekhenge ki ductility jo hai BCC ke case mein woh temperature dependent rahegi yani bahut kam ho jayegi at room temperature ya brittle keh sakte hain is material ko hum. Toh yeh saari cheezein yeh saare observation hum sirf Peierls-Nabarro stress ke ek equation se derive kar sakte ya samajh sakte hain.



Toh is part mein abhi main yahan ruk raha hoon par kuch points main yahan par likh leta hoon. Toh humne dekha yeh jo Peierls-Nabarro stress hai woh kis par dependent hai d ke upar inter-planar spacing, b ke upar ya d ko main is tarah se bhi likh sakta hoon ya Omega Omega ya w ke star se likh sakta hoon yeh jo w hai width of dislocation. Width of dislocation width of dislocation ko $d/(1-\nu)$ ki tarah likha tha. Toh agar hum dekhenge ki d badhega aur b ghatega toh mera jo Peierls-Nabarro stress hai woh ghatega. Toh yeh relation aapko yaad rakhne hain Peierls-Nabarro stress ke.

Next part mein hum janenge ki dislocation movements kaise hote hain. Abhi humne yahan tak dekha ki stress kitna lag raha tha dislocation ko move karne mein. Par jab dislocation move hota hai toh material mein kya plastic strain develop hoga yeh hum agle parts mein janenge.

Dhanyavad.