

Mechanical behavior of materials

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Week-8

Lecture-40

Dislocation and Stacking Sequence in BCC



Mechanical Behavior of Materials (Hindi)

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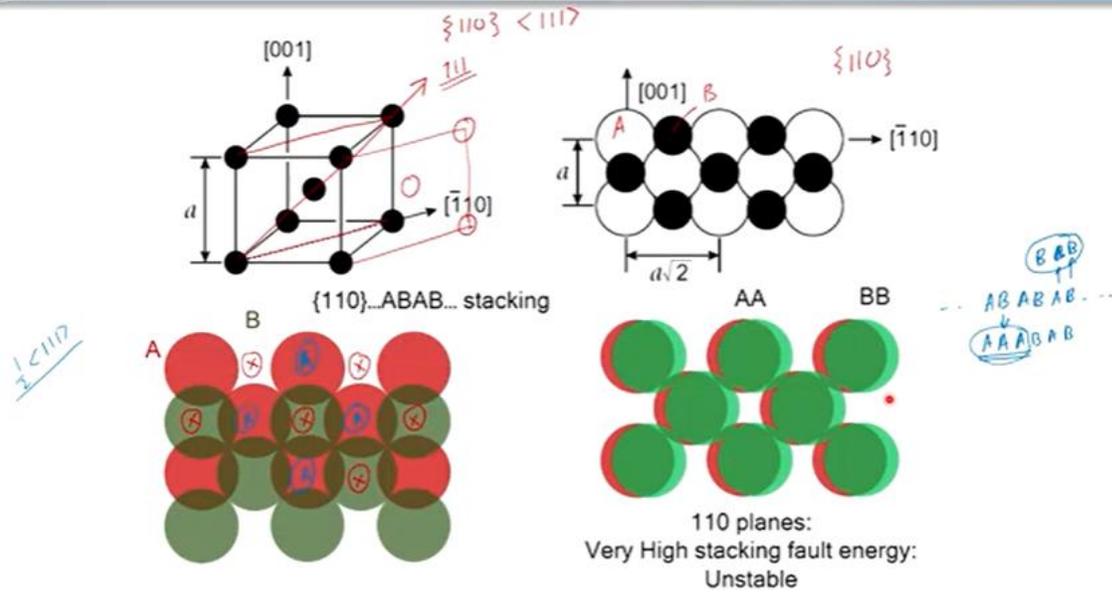
Namaskar aapka swagat karta hoon mechanical behavior of material is course mein jo ki hum hindi mein padhenge last part tak humne dekha ki stacking sequence kya hota hai FCC mein aur partials kya hote hain super partials kya hote hain super lattice mein jaise ki ordered structures mein is part mein hum jaanenge ki dislocations aur stacking sequences kya hote hain BCC structure mein to abhi jab main stacking ki baat karta hoon tab stacking ek kisi particular plane ke liye hi hoti hai to abhi hum dekhenge ki BCC structure pehle kya hai hum ye ek BCC structure hai jahan pe mere atoms kuch corners pe hai aur ek atom mera body centered pe hai jab hum slip systems ki baat karenge to slip system yahan pe main likh leta hoon to yahan pe humein pata hai ki $\{110\}$ type jo planes hote hain wo planes hote hain aur $\langle 111 \rangle$ direction ye meri slip direction hai to agar main ye (110) plane yahan par plot karunga ya dikhaunga yeh dekhiye yahan par ek (110) plane maine mark kiya hai is tarah se aur agar dusra (110) plane main kuch mark karunga to wo kuch is tarah se aayega agar main dusre unit cell mein jaunga to aur main inko agar project karke is tarah se plot karunga to mere paas kuch is tarah se stacking milegi yeh meri stacking ho gayi mere (110) planes

ki ye mere do (110) planes hai ek plane ko main naam deta hoon A aur ye jo dusra plane hai ya dusra (110) plane hai aur dusra stack hai (110) plane ka isko main naam deta hoon B.

Abhi aap dekh paa rahe honge ki jo A plane hai uska ek kuch atomic arrangement hai aur B plane hai uska ek atomic arrangement hai jo ki A ki tarah hi hai par yeh jo B plane hai wo yeh position occupy karta hai jo ki A layer mein jo interstices hai yaani jo jagah bachi hai atoms ke beech mein wahan pe occupy karta hai agar main teesra plane mark karunga to wo A plane ki tarah hi hoga to mujhe stacking milti hai *ABAB* stacking to yahan par beech mein mera B layer aayega to yeh B layer kuch is tarah se occupied hota hai jaani dekhte hain ki iske baare mein jo A layer aur B layer kis tarah se stacked hai to mera yeh A layer is tarah se stacked hai aur B layer ki position is tarah se aap dekh paa rahe honge ki meri B layer ki position yahan par hai kuch yahan par is tarah se jahan par A layer mein space available hai to aur aap dekhenge ki yeh jo yeh jo B layer hai kuch is tarah se stacked hai abhi hum dekhenge ki $\langle 110 \rangle$ ya $\langle 111 \rangle$ direction ya slip direction kahan pe hai to hum agar dekhenge is plane mein is plane mein slip direction hamari body diagonal hogi to yeh meri ek $\langle 111 \rangle$ direction hai to yahan pe agar dekhenge to $\langle 111 \rangle$ direction meri kuch is tarah se hogi yahan pe ek B to B ya A to A yaani center to center kyunki aap dekhenge yeh jo direction hai ye meri close packed direction hai ye saare jo jahan pe atoms touch ho rahe hai ye close packed direction hai ye meri $\langle 111 \rangle$ direction hai jab hum slip slip ki baat karte hain BCC mein to hum dekhte hain ki do layers glide ho sakte hain to yahan pe karte hain A aur B layer jab hum consider kar rahe to B layer ko glide karte A layer ke upar aur wo glide hoga mere slip direction ke along to slip direction yaani mere $\langle 111 \rangle$ direction ke along to abhi isko glide karte hain to humein jo stacking hai yahan pe main plane ki ye *ABAB* stacking humein milti hai to kuch is tarah se yaani A A layer mera yahan pe aayega to abhi isko hum is tarah se bhi samajh sakte hain mera jo A layer hai wo yahan pe aayega B ke is positions pe to mujhe jo stacking mil rahi hai wo *ABAB* stacking milti hai BCC structure mein aur stacking kaun si hai (110) planes ki stacking aapko hamesha yaad rakhna hai jab main stacking ki baat karunga to aap particular plane ke baare mein hi baat karenge aur yeh jo particular plane hai yahan par main baat kar raha hoon yeh (110) plane hai abhi in planes ko main glide karta hoon $\langle 111 \rangle$ direction pe yaani agar ismein slip direction dekhun to shortest lattice translation vector mera $\langle 111 \rangle$ $1/2\langle 111 \rangle$ hai to main in isko is direction mein glide karunga kuch is tarah se to aap dekhenge ki jab main glide karunga to yeh B position ye dusre B position par occupy ho jayegi to aap dekhenge ki ye glide karne se koi stacking fault yahan pe taiyaar nahi ho raha hai mujhe A aur B layer us tarah se intact mil rahi hai to mujhe koi stacking faults yahan pe milenge nahi to agar main kuch is tarah se atomic arrangements karoon jahan pe mujhe kuch stacking fault mile to aap dekh paa rahe honge ki mujhe *AA* ya *BB* layer milegi to humne yahan par dekha hai ki (110) jo stacking hai *ABAB* is tarah se hai to aap dekhenge agar main B ko move karta hoon mere ek slip distance hai to ye B phir se A ban raha hai to aap dekh paa rahe honge ki yahan par mere paas kuch is tarah se layers banegi ya agar main kisi isi mein B ko move karunga ya A ko move karunga to mere paas yeh A rahega ye yeh B ho jayega aur yahan par mujhe *BBB* stacking milegi ya *AAA* stacking milegi kuch is tarah se uski arrangement rahegi to yeh jo arrangement hai yeh highly energetic arrangement hai yahan pe ye jo arrangements thi ye meri equilibrium yahan pe energy lowest thi to par yeh jo arrangement hai atoms ki (110) planes ki ye highly unstable hai kyunki yahan par jo energy configuration hai wo high hai aur isi ko hum kehte hain ki very high stacking fault energy yahan pe mujhe sabse jyada stacking fault energy is configuration mein rahegi to yeh jo arrangement hai wo unstable rahegi to humein (110) pe koi stacking faults nahi milte BCC mein.

To abhi dekhte hain ki (112) planes par stacking faults milte hain ki nahi to humne dekha tha ki ek aur slip system hoti hai BCC mein main yahan par likh leta hoon ki {112} planes hote hain aur slip direction ismein bhi $\langle 111 \rangle$ hoti hai to aap dekhenge ki yeh plane jo hai {112} planes.

Dislocation and stacking sequence in BCC



Yeh kis tarah se arrange hai BCC structure mein uske liye hum jaante hain ki ek do unit cell consider karte yahan par maine do unit cell consider kiye BCC ke ek ke upar ek is tarah se yeh ek unit cell hai ek ye ek unit cell aur aap dekh paa rahe honge yahan par kuch atoms maine mark kiye ya particularly yahan par maine {112} planes pehle mark kiye to dekhte hain ki wo {112} planes kahan par hai to mere yeh {112} planes hai yahan pe aap dekh paa rahe honge yeh kuch {112} planes hai main saare {112} planes nahi mark kar raha hoon jo dikhne mein aasaani hai so (112) planes ko mark kar raha hoon aur aap dekh paa rahe honge ki ek (112) plane pe jaise maine A atoms mark kiye ye dusra (112) plane hai jis pe maine B atoms mark kiye phir C atoms phir D atoms E atoms aur F atoms ye kitne ABCDEF yeh kuch is tarah se layers yahan pe (112) ki maine mark ki ya stacking maine yahan pe (112) ki mark ki hai to (112) mein kuch is tarah se stacking hoti hai stacking sequence hota hai ABCDEF aap dekh paa rahe honge ki main A se A jab move hota hoon do stack karta hoon is tarah se planes ka to mujhe do unit cells milte hain BCC ke to ye stacking available hoti hai meri (112) planes ki BCC structure mein to ye bhi ek slip system hai BCC mein to agar aap dekh paa rahe honge ki ye jo (112) planes hai yahan par kuch directions mark kiye hai to aap dekh paa rahe honge ye particular ye $(1\bar{1}2)$ plane hai to ye direction hai yahan pe ye perpendicular hai is plane ko aur abhi hum kya karenge agar mujhe dislocation ya stacking fault samajhne hai BCC mein (112) planes ke liye to mujhe main ek trace nikalta hoon trace kis tarah se nikalta hoon main yeh $(1\bar{1}2)$ planes ka trace nikalta hoon (110) plane par to yeh trace kis tarah se nikalte hain isko samajhte hain agar main kuch is tarah se le raha hoon agar main yeh mera yeh mera (110) plane main mark kar raha hoon yeh (110) plane maine mark kiya hai aur abhi main kya karunga yeh jo saare atomic layers hai saare atomic atoms hai is (110) plane pe main project karunga project is tarah se karunga ki yeh jo meri $\langle 110 \rangle$ direction hai yeh perpendicular rahegi plane ko to aap dekh paa rahe honge yeh maine trace nikaala yahan pe aur yeh jo direction hai ye $\langle 110 \rangle$ direction hai yahan pe aur yeh trace maine is tarah se nikaala hai aap dekh paa rahe

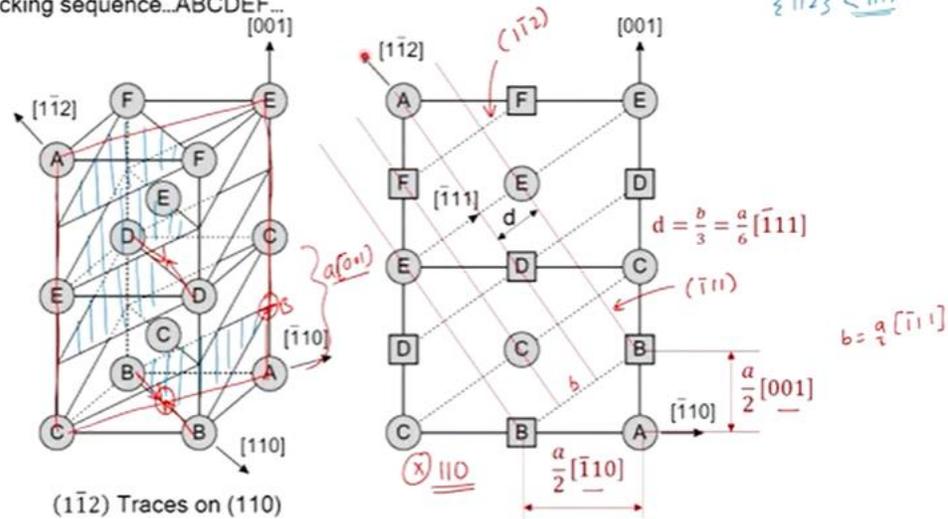
honge ki main projection is tarah se kar raha hoon jaise maine B atom ko project kiya is plane par to mera B atom kuch is tarah se dikhega yaani saare atoms main is $\{112\}$ plane ke is plane par project karunga to D atom kuch is tarah se niklega to aap dekh paa rahe honge ki A atom jab main project karta hoon yeh (110) plane pe kuch is tarah se to aap dekh paa rahe honge ki A atom yeh position par hai C atom mera is position pe aur B atom aap dekh paa rahe honge beech mein aa gaya to to ye ek projection ho gaya mere B atoms ka yaani (112) plane ka (110) plane pe isko hum kehte hain trace kehte $(1\bar{1}2)$ plane ka (110) plane pe.

To aap dekh paa rahe honge abhi hum kuch distance mark karenge is trace ke trace ke upar to ye jo distance hai pehla to aap dekh paa rahe honge yahan pe B agar hai to ye distance hai B aur A ka yahan pe aayega $a/2[\bar{1}10]$ kyunki aap dekh paa rahe honge ye jo direction hai yahan ye $[\bar{1}10]$ hai aur yahan par ye $[\bar{1}10]$ is tarah se mark kiye aur yeh jo distance hai ye half hai to isliye ye jo distance ho gaya ye $a/2[\bar{1}10]$ hoga abhi aap dekhenge ki A aur B ka maine distance mark kiya hai to yahan pe ek B ka projection aayega is beech mein aur A aur C ka distance mera $a[001]$ rahega isko bhi mark kar lete hain yeh jo distance hai yeh rahega $a[001]$ aur iske aadha distance yahan pe aayega yeh mera B layer hai to yeh B layer yahan pe mark kiya to yeh jo aadha distance hai yeh aa jayega $a/2[001]$ aap dekh paa rahe honge ki agar main B aur B ka distance yahan pe nikalu to ye aa jayega mera Burgers vector aur iski magnitude aap nikalenge in dono vectors ke summation se to ye aa jayega $a/2[\bar{1}11]$ kuch is tarah se to yahi mera Burgers vector hai to C to C ya D to D ya E to E F to F ye jo distance hai ye ho jayega mera Burgers vector abhi main kuch planes mark kar raha hoon to aap dekhenge ki mera jo $(1\bar{1}2)$ jo plane hai ye yeh planes hai kyunki ye jo direction hai is planes ko perpendicular hai to isko bhi mark kar lete hain jo dashed lines mein projected hai ye mere $(1\bar{1}2)$ planes hai aur abhi aap dekhenge ki ye jo direction hai $[\bar{1}11]$ ye direction ko perpendicular jo planes rahenge wo mere $(\bar{1}11)$ plane rahenge to ye jo red mein maine mark kiye ye mere $(\bar{1}11)$ plane hai to is planes ko bhi hum likh lete hain ye planes jo hai mere $(\bar{1}11)$ plane hai abhi hum dekhenge ki agar main E to E agar distance dekh raha hoon to yahan pe mere paas is E to E ye Burgers vector hai yahan pe ye jo magnitude hai E to E distance ye Burgers vector ke barabar hoga aur yahan par yeh teen hisson mein bata hai to mere paas jo interplanar spacing aayegi $(\bar{1}11)$ plane ki ye isko main d consider kar raha hoon aur yeh d aayegi $b/3$ kyunki yeh jo E to E distance hai ye mera Burgers vector hai to ye $b/3$ aayegi aur humein b pata hai ye hai $a/2[\bar{1}11]$ to ye jo d hai kuch is tarah se main likh paunga specifically yahan par main karunga to yeh kuch is tarah se rahega to yahan par maine ek interplanar spacing bhi nikaal di hai.



Stacking of {112} in BCC

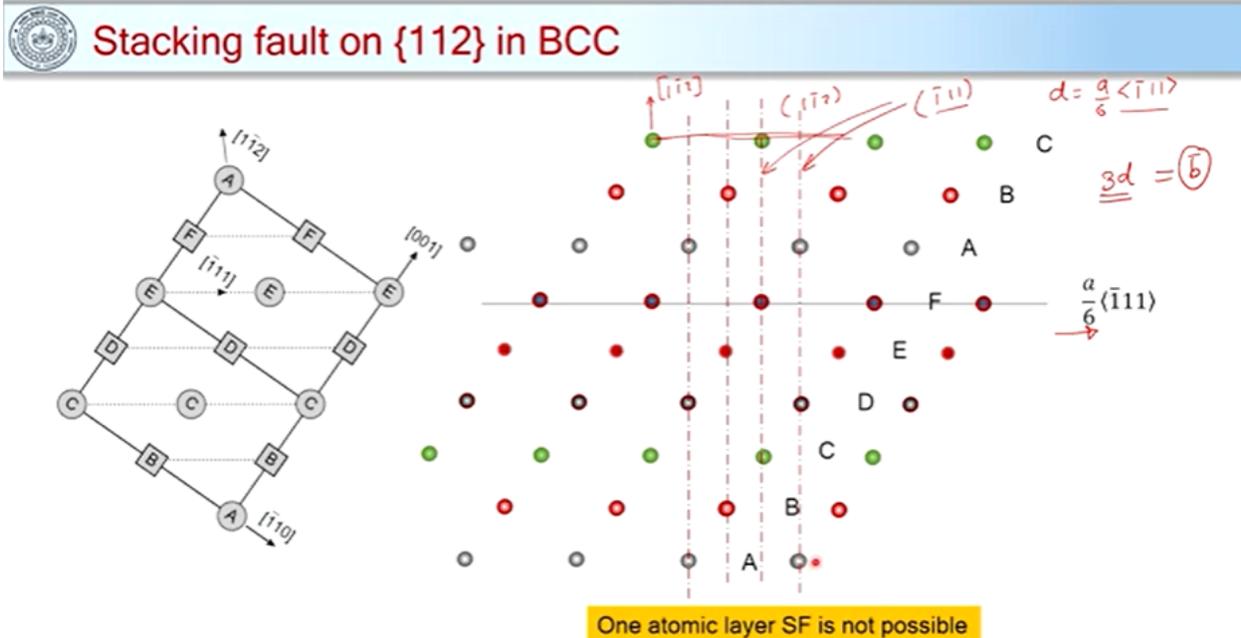
{112} Stacking sequence...ABCDEF...



Introduction to dislocations, Hull & Bacon

Abhi yeh jo trace nikaala hai iske iski upayuktata hum jaanenge aur iska istemal karke hum stacking fault create karne ki koshish karenge ye plane pe jo ki mera $(\bar{1}\bar{1}2)$ plane jo hai ye mera ek slip plane hai to maine kuch is tarah se arrangement kar liya agar aap dekhenge ye mera trace tha aur yahan par maine kuch is tarah se layers bana liye ABCDEF aur ABC is tarah se meri BCC ki stacking nikaal di aur yeh agar plane main consider karunga aap dekh paa rahe honge ye jo plane hai mera yahan pe $(\bar{1}\bar{1}2)$ direction hai to yeh jo plane hoga yeh mera $(\bar{1}\bar{1}2)$ plane hoga aur yahan par jo planes honge is direction ko perpendicular to ye direction hai meri $[\bar{1}11]$ abhi main kya karunga main ek kaam karunga ye jo A layer hai yeh main glide karunga kisi ek layer par jaise main F layer par main reference maan raha hoon is layer par maine agar mujhe stacking fault taiyaar karna hai to main kuch layer ko glide karne ki koshish karunga kuch is tarah se main glide kis tarah se karunga abhi main glide karunga is position se yeh meri reference position hai aur glide main kuch is tarah se karunga to aap dekhenge ki maine is tarah se glide kiya aur yeh jo distance hai ye glide distance jo hai ye mera kyunki ye do $\{112\}$ plane hai $\{112\}$ layers hogi ye ye meri yahan pe ye $(\bar{1}11)$ planes hai kyunki wo is direction ko perpendicular hai to agar aap dekhenge in dono ka distance kitna tha humne nikaala tha $d = a/6\langle 111 \rangle$ ye distance jo hai $(\bar{1}11)$ hai to main jo glide kiya yahan pe wo is magnitude se glide kiya aap dekhenge ki position yahan pe thi atom ki wo yahan pe aa gayi to aap dekh paa rahe honge ki mera jo A layer hai wo F layer ke just above hai to ye jo configuration hai yeh yahan pe stable nahi ho sakti kyunki dono ek layer dono layer ek dusre ke upar hai abhi main phir se glide karta hoon is magnitude se d se to aap dekhenge ki A layer E layer ke upar hai yaani ek ke upar ek A aur E layer aa gayi hai to yeh bhi jo configuration hai yeh bhi highly energetic configuration hoga to yeh bhi configuration meri possible nahi hai abhi main phir se is direction mein move kiya is magnitude se to mujhe yeh position mili par aap dekhenge ki main agar three times move karunga to main initial position pe aa jaunga kyunki ye mera Burgers vector hai to maine three times d se move kiya to three times d ye mera Burgers vector hai to main initial position par aa jaunga aur yeh jo yeh jo position hai wo meri yahi layer hai to aap dekh paa rahe honge ki yahan pe main ek conclusion kar sakta hoon ki One Atomic Layer Stacking Fault possible nahi hai BCC ke case mein jab main $\{112\}$ pe stacking

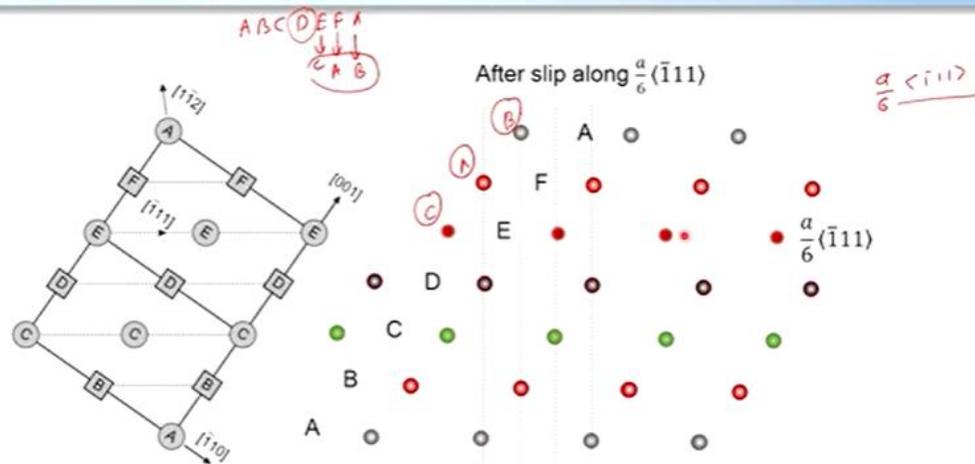
fault taiyaar karne ki koshish kar raha hoon to aap dekh paa rahe honge ki kisi bhi case mein mujhe



stable configuration nahi mili to one layer stacking fault possible nahi hai BCC ke case mein abhi hum dekhte hain ki maine stacking fault jab create karne ki koshish kar raha hoon to main maine phir se kuch arrangement yahan par de diye abhi humne one layer nahi kiya abhi hum hum kya karenge hum kuch multiple layers ko glide karenge aur glide kis direction mein karenge glide hum isi direction mein karenge jo ki isko bhi likh lete hain wo hum karenge $a/6[\bar{1}11]$ direction pe aur maan lete ki pura do teen layers hum glide karne ki koshish karenge is direction mein aur yeh slip hogi along ye $a/6[\bar{1}11]$ is tarah se to agar main glide karne ki koshish kar raha hoon ya ye teenon planes ek ek hi saath agar maine glide kiye to aap dekh paa rahe honge ki yeh jo yeh jo layer hai yahan par aap dekh paa rahe honge meri E layer yahan par thi ab yeh E layer meri C layer ho gayi hai yahan pe yeh C layer ho gayi hai aur yeh jo F layer hai wo A layer ho gayi hai aur meri B layer jo A layer hai wo B layer ho gayi hai to aap is tarah se samajh sakte hain to agar mere paas ABCDEF hai aur humne abhi glide kiya D ke upar to E layer meri C layer ho gayi aur F layer ye yahan par meri F layer thi F layer meri A layer ho gayi hai aur yahan par jo A layer thi wo meri B layer ho gayi hai to yeh yeh ek dusre ke upar nahi hai to yeh possible hai yahan pe to main yahan par dekh paa raha hoon ki agar main stacking fault create karne ki koshish kar raha hoon aur main multiple layers agar glide karta hoon to mere paas ek stable energy aur stable stacking fault taiyaar ho sakta hai to hum yeh dekh sakte hain ki agar multiple layers agar main glide karta hoon ek saath to mere paas ek stacking fault taiyaar ho sakta hai BCC ke case mein.



Stacking fault on {112} in BCC



Stacking fault due to glide on consecutive {112}: Stable

Humne dekha is part mein ki BCC mein single layer ka stacking fault possible nahi hai par multiple layers ka stacking fault main taiyaar kar sakta hoon iske implication dekhenge jab hum twinning ke baare mein jaanenge BCC ke case mein to is part mein humne BCC ke stacking sequence dekhe to humne dekha ki (110) planes par koi stable stacking fault hum taiyaar nahi kar sakte par {112} ke case mein hum single layer stacking fault taiyaar nahi kar sakte but multiple layers agar main glide karta hoon {112} planes ke to main stable stacking fault taiyaar kar sakta hoon iski upayuktata hum jaanenge BCC ke case mein jab hum uske twinning ke baare mein padhenge abhi ke liye rukta hoon dhanyavad