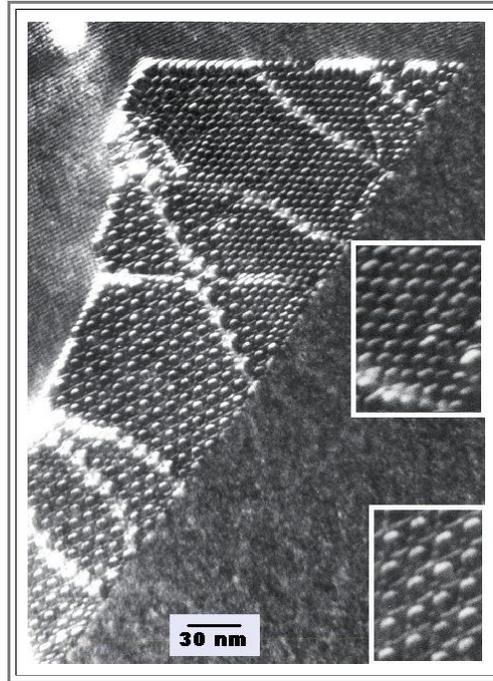


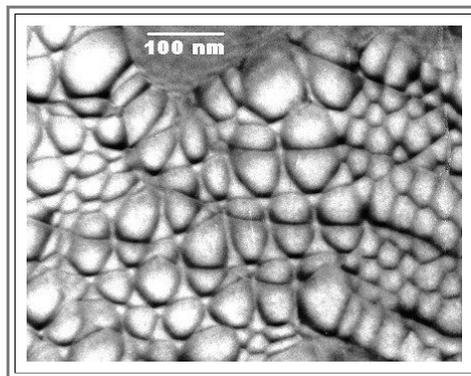
## Complications in a Low Angle Twist Boundary on {111}

### Advanced

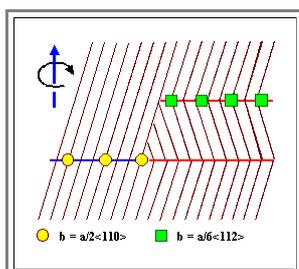
- Here is the picture of a small angle twist grain boundary [once more](#) at a larger size. The transition from one kind of network to the other kind is not prominent in the micrograph; the prominent white lines are extrinsic dislocation accommodated in the network.
- The topic in this module is not something you have to know for an examination, or for being considered knowledgeable about defects. It just illustrates two general points about grain boundaries:
  - Even relatively simple situations can become very complicated (for us, not for the crystal).
  - Seeing a boundary in the electron microscope, and understanding what you see, is not the same thing.



- Below is essentially the same situation showing the same kind of small angle twist boundary, but imaged with some special kind of bright field condition that gives good resolution and shows all dislocations at the same time. The changes in the network can be seen somewhat more clearly; the twinned region is on the right hand side.

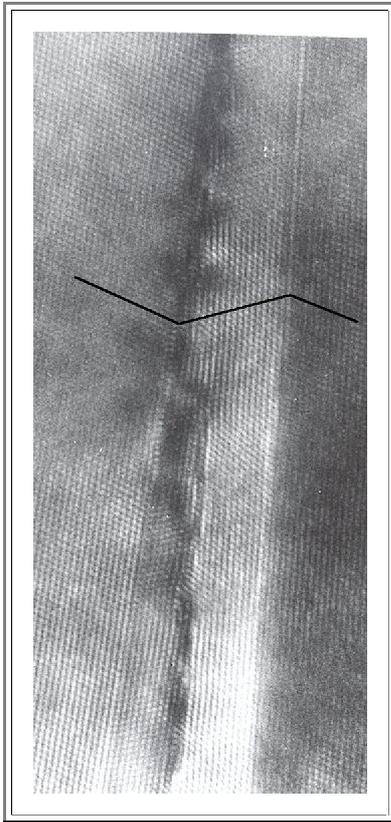


- In a cross-section, the whole structure looks like this:

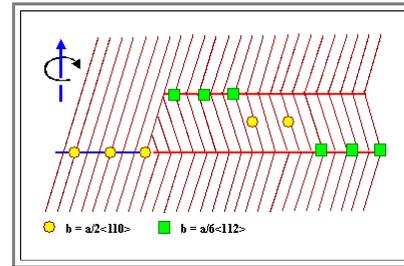


- The traces of some {111} lattice plane across the twist boundary are shown; neglecting the (small) twist for sake of clarity.
- The boundary may split into *two* twin boundaries with a superimposed network of the proper DSC lattice dislocation (shown as green squares)

- This picture, however, gives rise to a question: Where is the network of  $a/6\langle 112 \rangle$  dislocations? In the "upper" or "lower" twin boundary? Could it also be in between as a regular network of  $a/2\langle 110 \rangle$  dislocations split into partials?



- This picture gives the answer. It shows a **HRTEM** cross-section of an artificially made small angle grain boundary in **Si**. It contains a large tilt component and probably some twist.
- The dislocations can be seen, partially as ending lattice planes, partially by a general localized disturbance of the picture (darkish areas).
- They obviously change from the perfect crystal ( $\Sigma = 1$  case) to one of the twin boundaries ( $\Sigma = 3$  case). In the  $\Sigma = 1$  case we would see the network with the extended and constricted stacking fault nodes, in the  $\Sigma = 3$  case we would see a regular hexagonal network of  $\mathbf{a}/6\langle 112 \rangle$  dislocations.
- We thus may have to expect all the possibilities shown below:



▀ This means, among other things:

- If we see a dislocations network clearly belonging to a  $\Sigma = 1$  case, it does not mean that the grain boundary is not split into twins. Possibly, this may even be true for a  $\Sigma = x$  boundary, which may be split into two boundaries with  $\Sigma = y$  and  $\Sigma = u$  with a suitable relation between  $y$  and  $u$ .
- It is not easy to understand why the crystal does this. For our case we might surmise that the energy gain by having low energy  $\mathbf{a}/6\langle 112 \rangle$  dislocations in a  $\Sigma = 3$  interface is about equal to the energy needed to create the two twin boundaries since both possibilities occur without much preference between the two.