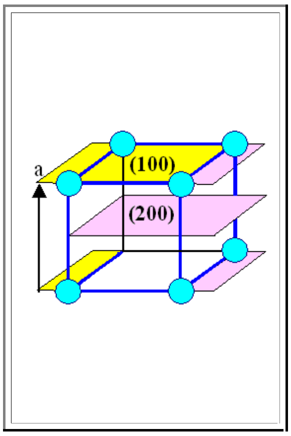
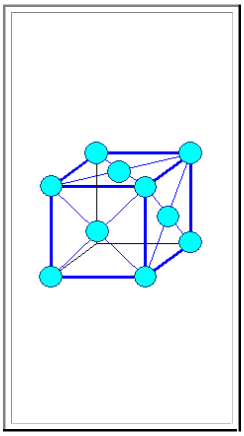
Stacking Faults in the DSC Lattice

Illustration

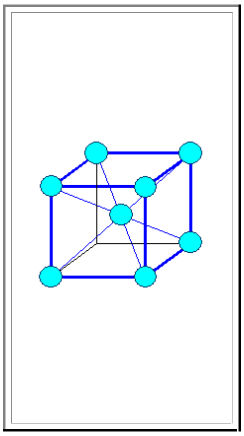
- In a *crystal* , a *lattice* point may be the seat of more than one atom, and the arrangement of atoms may have a higher degree of symmetry than the lattice.
  - In Bravais lattices, which are not necessarily the primitive lattices of a crystal, this feature expresses itself in the fact that lattice planes that *do not contain lattice points* of the elementary lattice, *may still contain atoms*.
  - Let's illustrate this somewhat abstract concept with the familiar **fcc** and **bcc** Bravais lattice with an atom on every lattice point



Cubic primitive lattice: Atoms are found on *all* **{100}** planes and on every *second* **{200}** plane. The *set* of **{100}** and **{200}** planes is shown on the left and right of the drawing, respectively

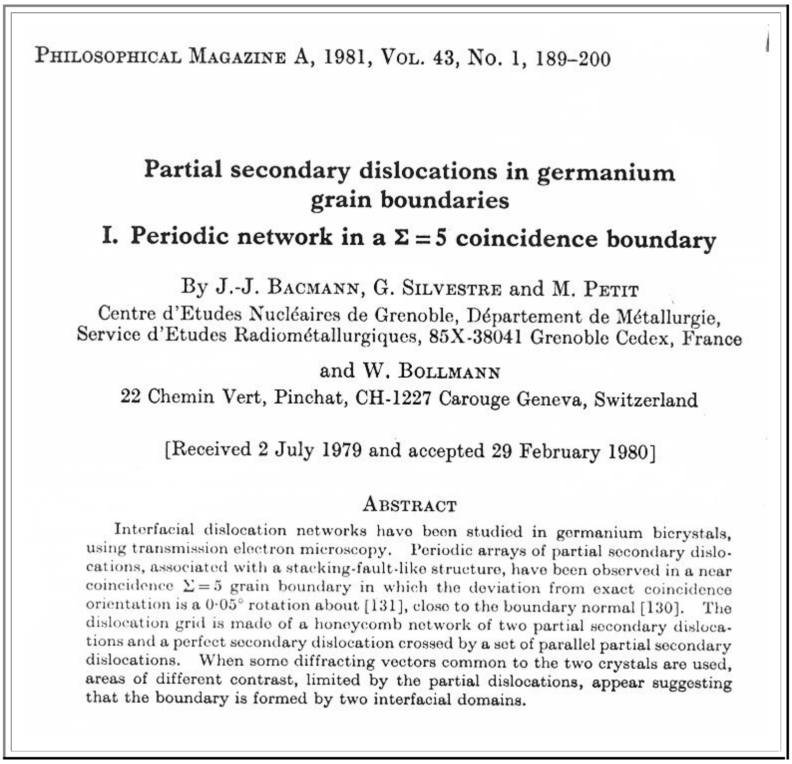


Cubic face-centered lattice: Atoms on *all* **{100}** planes and on all **{200}** plane with the same basic arrangement, just shifted by **a/2<010>** or **a/2<001>**.



Cubic body-centered lattice: Atoms on *all* **{100}** planes and on *all* **{200}** plane with the same basic arrangement, just shifted by **a/2<011>**.

- In terms of defects, this feature allowed for *stacking faults* in the *crystals*, which could not meaningfully exist just in the *lattice*.
- Well, the **CSL** lattice and the **DSC** lattice are *lattices*, after all. But physical reality still rests with the atoms. This may have somewhat exotic consequences.
  - The **DSC** lattice is a lattice that contains both lattices of the two crystals forming a **CSL** boundary as subsets. All atoms sitting on a *lattice point* of the crystal lattices therefore are also sitting on a *lattice point* of the **DSC** lattice
  - However, atoms *not* sitting on lattice points of the crystal lattices, may also *not* sit on lattice points of the **DSC** lattice. In analogy to the example above, there might be some additional symmetries hidden in the **DSC** lattice if we consider all atoms forming the crystals and their positions in the **DSC** lattice. In particular, the stacking of planes of the **DSC** populated with atoms may allow **stacking faults in the DSC lattice**, too, inextricably linked to **partial dislocations in the DSC lattice**.
- Since reality is (almost) always stranger than fiction, you *should expect* that this will happen - look out for stacking faults in the **DSC** lattice, and, as a corollary, **DSC** dislocation split into partial dislocations in the **DSC** lattice.
  - However, these defects in defects in defects may not be easy to find. Burgers vectors in the **DSC** lattice tend to be small which makes the contrast in **TEM** investigations (the only method with a chance at detecting this) rather weak. Partial **DSC** lattice dislocations would be even harder to see.
  - Moreover, the distance between secondary dislocations in the typical networks usually encountered, is mostly very small - there is not much room for splitting! Only in boundaries very close to a **CSL** orientation with roomy networks this effect may occur.
- So there is a good chance that you either never will see this or, if you see it, you may not recognize what you see.
  - You may even, and with good justification, be of the opinion that one shouldn't even look, because this topic is almost esoteric and is completely useless knowledge.
  - But some researchers *did* look and recognize - see below. Just for the hell of it, below the head of the article is reproduced as it appeared in "Phil. Mag."; i.e the **Philosophical Magazine**, which since its foundation in **1798** (which means it is one of the oldest science journals around) evolved into one of the major scientific journals covering **TEM** work in general and grain boundary stuff in particular.



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Partial secondary dislocations in germanium grain boundaries

I. Periodic network in a $\Sigma = 5$ coincidence boundary

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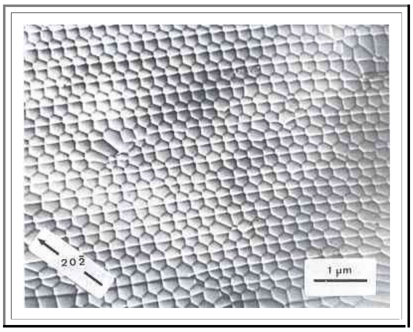
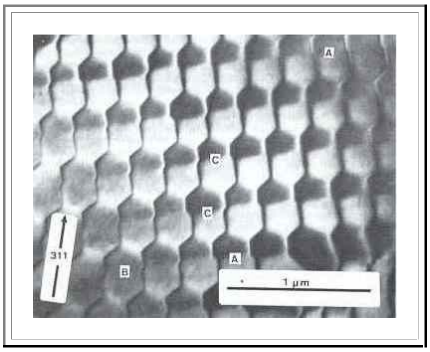
ABSTRACT

Interfacial dislocation networks have been studied in germanium bicrystals, using transmission electron microscopy. Periodic arrays of partial secondary dislocations, associated with a stacking-fault-like structure, have been observed in a near coincidence $\Sigma = 5$ grain boundary in which the deviation from exact coincidence orientation is a 0·05° rotation about [131], close to the boundary normal [130]. The dislocation grid is made of a honeycomb network of two partial secondary dislocations and a perfect secondary dislocation crossed by a set of parallel partial secondary dislocations. When some diffracting vectors common to the two crystals are used, areas of different contrast, limited by the partial dislocations, appear suggesting that the boundary is formed by two interfacial domains.

- Here are two pictures of what they found.





  - The left hand picture shows a dislocation network which is very unusual - nothing like it has ever been observed before with regular or **DSC** lattice dislocations. The right hand picture shows the same network, imaged under different diffraction conditions; the stacking faults in the **DSC** lattice are visible.
- There is a second article directly following the first one with **Bollmann** as a first author. It analyzes the interaction of lattice dislocations in one of the crystals with the partial **DSC** lattice dislocations in the boundary.
  - Not exactly easy stuff, it even taxed Bollmanns cunning. Suffice it to say that everything comes out as expected.

- We may use this issue for a little test. Answer the question below for yourself and then click on the "Yes" or "No" according to where the majority of your answers are found.

Question	Yes	No
Do you consider knowledge about grain boundary dislocations apocryphal because it has no immediate technical uses?		
If in your work you run across pictures like the ones above, can you sleep well at night without knowing what they mean?		
Would you, as the referee, turn down a proposal to expand the **CSL/DSC** lattice theory to **6** dimensions in order to see if it can be used to describe *grain boundaries in quasicrystals* because the results - if any - are not only going to be completely useless for applications, but of interest to at most **100** researches in the world?		
In awarding a big Materials Science and Engineering price, would you prefer the person who stands behind a big new product (e.g. the blue **LED**) based on essentially known science, to the person who first explained some major, but useless material property that so far was not understood?		