A Deeper Look at Dislocations

To the Editor:

Having worked on the crystallography, structure, and properties of silicon carbide ceramics over a number of years, I read the April 2005 issue of *MRS Bulletin* with some interest and admiration for all the advances that have been made in the last few years.

However, I wonder if I may take issue with the text accompanying the photographs occurring on the cover of the issue and that again on page 273. I believe there is some misinformation, or confusion, here which you would do well to sort out for the benefit of the younger researchers which follow us all down these various paths.

Firstly, spirals seen on the surface of crystals—as shown in the most beautiful photograph on your cover—do not necessarily mean that behavior is caused by a "screw" dislocation as such, even though that may be the most likely scenario; rather it has to be a dislocation with some degree of screw character. Back in the 1960s and 1970s, when I was researching in field ion microscopy, the incorrect belief that all spirals seen in atomic planes must be due to screw dislocations was widely held and was equally erroneous. All that such images show is that a Burgers' circuit taken around the point of emergence of the dislocation on the surface shows a closure failure which has a component in a direction normal to the surface. Unless you know where the line of the dislocation lies below the surface, it is impossible to say whether it is pure screw, predominantly screw, or anything else. Even pure edge dislocations, if sectioned correctly, can reveal atomic planes with helicoidal nature. Indeed, one of the original definitions of a dislocation (by Volterra) was that any defect which turned a set of perfect crystal planes into a helicoidal ramp was called a dislocation.

My second point concerns the beautiful picture of the hollow dislocation (as I believe was predicated by Cottrell) where I can only count six 6H unit-cell-high steps spiraling out from the center all of apparently equal contrast. This would give a Burgers' vector (or component of the Burgers' vector) as revealed by a surface Burgers' circuit to be 6c rather than 7c which is in the caption. Thus is there a step which is not imaging (which I believe can occasionally happen depending on the contaminants on the surface) or is one of the steps double (in which case it should show higher contrast than is apparent in the micrograph)?

Perhaps you could take note of my earlier points and satisfy my curiosity on the second.

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Response:

It is indeed true that the growth or dissolution spiral observed on the crystal face is not a proof of the screw character of the dislocation intersecting the surface. This point was made by H.P. Strunk in his article with a telling title: "Edge Dislocations May Cause Growth Spirals," (*J. Crystal Growth* **160** [1996] p. 184). Nevertheless, the images of growth spirals on the silicon carbide crystals are due to essentially pure screw dislocations. The growth direction most commonly adopted in SiC boule growth is [0001]. The growth surfaces (certainly the one shown in the figure) are almost perfect basal planes and the dislocations with the Burgers vector of nc[0001]-type have the line directions along the *c*-axis (M. Dudley, S. Wang, W. Huang, C.H. Carter Jr., V.F. Tsvetkov, and C. Fazi, *J. Phys. D Appl. Phys.* **28** [1995] p. A63). We have intentionally omitted most of the details of this type, focusing on the broad picture of the field.

On the other hand, the atomic force microscope image of the growth spiral does prove something by itself without the need for additional information. Namely, it proves that it is easier to operate the atomic force microscope than to count to six correctly. We sincerely apologize for the mistake.

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