Communications

Comments on a Recent Infinitesimal-Deformation Approach to Martensite Crystallography*

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Recently, Navruz[1] gave a reformulated infinitesimal-deformation approach to martensite crystallography, and he applied it to the fcc-to-bct transformation in Fe-7Al-2C.[2,3] That study contained three claims: (1) a better prediction of the shape-deformation magnitude m_1; (2) "excellent" agreement with predictions of the Wechsler–Lieberman–Read/Bowles–Mackenzie (WLR/BM) invariant-plane-strain theories,[4,5] and (3) (implied) a simpler alternative to the WLR/BM theories.

Here, we dispute all of these claims.

The first, and simplest claim is dismissed easily. Navruz claimed that his predicted shape-deformation magnitude $m_1 = 0.1274$ agrees better with observation (0.1220) than the WLR/BM value, 0.1379. However, Watanabe and Wayman[3] estimated a large error (20.8 pct) in their measured m_1; thus, $m_1 = 0.1220 \pm 0.0253$. Their measurement bounds include both the WLR/BM and Navruz predictions.

Second, as for "excellent" agreement between Navruz's theory and WLR/BM, we focus on the habit plane **p**, which is more sensitive than the orientation relationships discussed by Navruz. Although Navruz calculated **p**, he failed to point out the 7.3 deg discrepancy between his prediction and the average observed **p**. This is a large discrepancy. Habit planes are usually measured within 1 deg, and prediction-observation agreement is often within a few degrees. Because Navruz did not report the shape-change direction **d**, or sufficient information to compute it, we cannot compare his **d** prediction with the WLR/BM prediction, which would provide another sensitive test. Figure 1 shows the observed, Navruz, and WLR/BM **p** results plotted in the standard unit triangle. (The WLR/BM **p** coordinates given by Navruz are incorrect, and about 7 deg from the correct WLR/BM prediction.)

Third, Figure 1 also shows a curious feature of Navruz's **p** prediction: it is confined to the (0 *k l*) line, as shown also by the expressions for **p** in his Table II. One lesson from the WLR/BM theories and the related measurements is that habit planes are irrational with general indices (*h k l*). The value $h = 0$ imposes a severe constraint. Thus, the Navruz formulation must fail increasingly as habit planes move away from the (0 *k l*) curve. Other formulations of the infinitesimal-deformation approach also encounter the (0 *k l*) dilemma, for example, Khachaturyan[6] and Mura *et al.*[7]

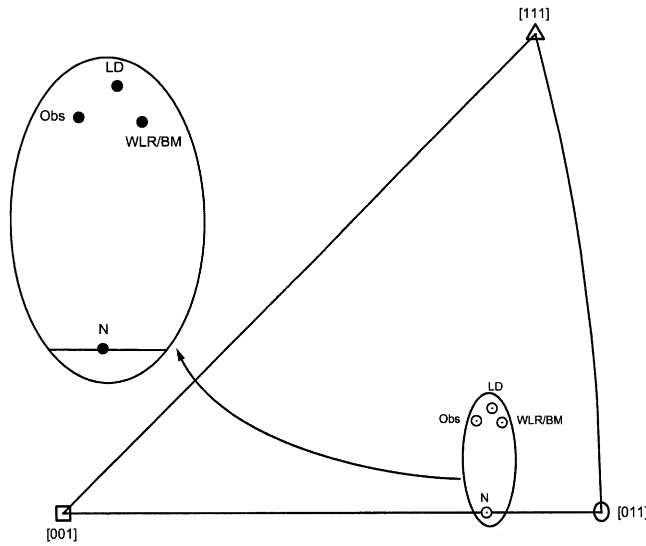

Fig. 1—Stereographic plot of habit-plane normals **p**. Navruz point is confined to the (0 *k l*) line 7.3 deg from observation. The WLR/BM point is 1.7 deg from observation. The Ledbetter–Dunn point is 1.7 deg from observation, taking a twinning fraction of 0.40. For the WLR/BM case, the twinning fraction is 0.38. If the martensite-plate aspect ratio is increased slightly from zero, the Ledbetter–Dunn theory gives *exact* agreement with observation.

Using an infinitesimal-deformation approach, Ledbetter and Dunn[8] found that **p** = (0 *k l*) if the lattice-invariant deformation is neglected. Later,[9] they showed that a correct treatment of the lattice-invariant deformation moves the predicted **p** from (0 *k l*) through the unit triangle up to the (*h h l*) line, that line corresponding to equal twin volumes. Thus, we conclude that the Navruz formulation is confined to predict (0 *k l*) habit planes near (011) and provides no useful alternative to the WLR/BM invariant-plane-strain approaches nor to the Ledbetter–Dunn infinitesimal-deformation approach, which includes WLR/BM as a special case, the zero-elastic-strain-energy case.[10] Figure 1 also shows the prediction of the Ledbetter–Dunn theory.

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Discussion submitted April 9, 2001.