Partial Dislocations - II

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Fall 2015
Intrinsic and Extrinsic Stacking Faults

Intrinsic Stacking Fault

Extrinsic Stacking Fault

Negative Frank Dislocation
S-Frank partial dislocation:
S = single fault

Positive Frank Dislocation
D-Frank partial dislocation:
D = double fault

[Hull & Bacon]
Remarks

• The Burgers vector of Frank partials is:

\[ \vec{b} = \frac{1}{3} \langle 111 \rangle \]

• \( \vec{b} \) is normal to \{111\}
• Frank partials are pure edge dislocations.
• Frank partials are sessile and can move only by climb

• Atoms are in wrong sequence in vicinity of stacking fault. There is a stacking fault energy (intrinsic or extrinsic).

• Stacking fault energy is only a local distortion of atomic layers. It is smaller than the grain boundary energy or surface energy.

• Stacking fault between Shockley partials is intrinsic SF.
Shockley Partial vs Frank Partial

- A partial dislocation whose Burger vector lies on the plane of the fault is called a **Shockley partial dislocation**.

- A partial dislocation whose Burgers vector is not parallel to the fault is called a **Frank partial dislocation**.

- Energy of a Shockley partial is approximately $1/3$ of the energy of total dislocation.

- Energy of a Frank partial is $2/3$ of the energy of total dislocation.

- Shockley partials are glissile but Frank partials are sessile.
Frank Partial Dislocations

The fault will be removed if the crystal above it is sheared such that:

\[ C \rightarrow B, \ A \rightarrow C, \ B \rightarrow A, \ \text{etc.} \]

This \( \frac{1}{2} <112> \) displacement corresponds to the glide of a Shockley partial.
Removal of Frank Partials

• To remove an intrinsic fault, one Shockley partial is required

• To remove an extrinsic fault, two Shockley partials are required.

\[
\frac{1}{6}[\bar{1}2\bar{1}] + \frac{1}{6}[2\bar{1}\bar{1}] + \frac{1}{3}[111] \rightarrow \frac{1}{2}[110]
\]

\[\alpha C + \alpha D + \alpha A \rightarrow BA\]
Twin

- Atoms move by less than a translational vector (< 1 lattice vector)
- We define twinning dislocation with the Burgers vector $b^*$

Fig. 3.10  Schematic illustration of a twinned region in the material: (a) before application of shear $\tau$ and (b) after twinning deformation. Note that the twinned region is a mirror image of the crystal part before twinning.
Burgers Vector for Twinning

• To define $b^*$ for twin:
  – Start on twinning plane
    Twining plane divides the mirror-image into 2 parts
  – Make circuit of $n$ step
  – Last step is parallel to the first step
  – $b^*$ lies in twining plane

• $b^*$ = translation needed on each plane to restore perfect crystal
Twin

- Twin plane in fcc = \{111\}
- Twin direction in fcc = <112>

- Twin is an imperfect dislocation
  \[ \vec{b}^* = \frac{a}{2}[\overline{1}12] \]
- Distance moved by each layer is proportional to distance from twin plane
Frank’s Index for Twin

<table>
<thead>
<tr>
<th>Layer #</th>
<th>w/o twinning</th>
<th>w/ twinning</th>
<th>Frank’s Index</th>
<th>Structure</th>
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<tr>
<td>-2</td>
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<td>B</td>
<td>Δ</td>
<td>FCC</td>
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<tr>
<td>-1</td>
<td>C</td>
<td>C</td>
<td>Δ - - - -</td>
<td>H.C.P.</td>
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<tr>
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<td>A</td>
<td>Δ - - - -</td>
<td>H.C.P.</td>
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<td>C</td>
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<tr>
<td>3</td>
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<td>B</td>
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<tr>
<td>4</td>
<td>A</td>
<td>A</td>
<td>Δ - - - -</td>
<td>H.C.P.</td>
</tr>
</tbody>
</table>

- Single layer of atoms having hcp stacking
Energy of Twin

• $\gamma_E \approx \gamma_I \approx 2\gamma_T$

Figure 9.24. The relationship of stacking fault energy and twin boundary energy. The line represents $\gamma_{\text{stacking fault}} = 2\gamma_{\text{twin}}$. 
Stacking Fault and Twinning

- The negative Frank partial has one late twin on tension side.
- The positive Frank partial has a two layer twin on compression side.

Intrinsic Stacking Fault
Extrinsic Stacking Fault