CHAPTER VIII
SLIP AND SCREW DISLOCATIONS IN DIAMOND

8.1 Introduction

During the investigations on the microstructures of the octahedral faces of natural diamond an interesting observation was made which confirmed the evidence of slip and screw dislocations in diamond. The present chapter has been devoted to the optical and interferometric studies of these features.

Reports on the existence of crystallographic slip on diamond are not very common. Williams (1932) has suggested that some of the lines observed on natural diamonds might be due to slip and Tolansky and Omar (1953) have described a case of possible slip on opposite octahedron faces of a twinned diamond, as mined. Seal and Menter (1953) used electron microscopy for the investigation of surface features on polished diamonds. Their observations suggest that plastic deformation may be produced in the act of polishing diamond which would give rise to the crystallographic slip observed. Tolansky, Halperin and Emara (1956) observed linear discontinuities
strictly in (111) planes on the natural octahedral faces of a diamond. After an optical study of these lines they have concluded that the slip hypothesis is the only reasonable one which accounts for the observed characteristics of such lines.

While carrying out investigations on microstructures of the octahedral faces of some South African micro-diamonds of octahedral habit a crystal which was of interest, was found. On the two (111) faces of this crystal, a sharp line running on each of these in <110> direction from one of the edges of the octahedral face and terminating in the middle, was observed. Since slip occurs in diamond along {111} planes and these planes intersect themselves in <110> direction, it was conjectured that the sharp lines mentioned above might be slip lines terminating on the faces. The interferometric and optical studies made on these lines are given below.

8.2 Observations

Figure 77 (X 55) represents the three (111), (111) and (111) adjacent faces of an octahedron. The slip reported here is observed on the (111) and (111)
faces. It is easily seen in figure 77 that on the face (111) from the point marked 'B' and on the face (111) from the point marked 'A', sharp straight lines run in <110> direction. These lines slowly fade and ultimately terminate on the respective faces but do not run right across the entire face. On the middle (111) face, a line is seen joining the two lines described above on (111) and (111) faces. This line is slightly curved. In order to find what do these lines represent on the faces their nature was studied by multiple beam interferometry. Thus figure 78(X 55) represents the interferograms obtained on faces shown in figure 77. The investigations made on each face separately from the respective interferograms are given below.

(1) Slip line on (111) face

The interferogram on (111) face clearly reveals that the sharp line is not a crack on the surface but a sharp discontinuity in the level. It also reveals that the magnitude of the step progressively decreases as one moves from B along the line on the face and ultimately it vanishes. The magnitude of the step at few points along the line was determined.
from the interferogram and was checked up by fringes of equal chromatic order (as shown in figure 79). The height of the step measured at various distances from the point B is given in Table No. 8.1.

**TABLE NO. 8.1**

<table>
<thead>
<tr>
<th>Distance from the edge in millimeters</th>
<th>Step height in Angstroms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0358</td>
<td>2005</td>
</tr>
<tr>
<td>0.1911</td>
<td>1640</td>
</tr>
<tr>
<td>0.3584</td>
<td>1260</td>
</tr>
<tr>
<td>0.5311</td>
<td>885</td>
</tr>
<tr>
<td>0.7026</td>
<td>481.6</td>
</tr>
<tr>
<td>0.3306</td>
<td>190</td>
</tr>
</tbody>
</table>

Figure 80 represents a plot of the step height against the distance, which clearly reveals that the step vanishes at a point distant 0.92 mm from the point B. If the distances of the points at which the step height is determined are measured from the point where the step vanishes then it is found in this case that the step height is
proportional to the respective distances. Since the slip terminates on the face, the point of termination should be a screw dislocation (Amelinckx, 1952). Slip has thus produced a screw dislocation on the octahedral plane. The slip is 2080 Å at the edge of the crystal from where it is initiated and is zero at a distance of 0.92 mm from the edge where it vanishes. This corresponds to a very small angle of $2.28 \times 10^{-4}$ radians i.e. approximately 47 seconds of an arc, between the two slipped regions. This angle would imply a displacement of one atomic lattice in $10^4$ lattices.

The slip line divides the face into two regions:

(i) The region towards the base and
(ii) Towards the apex.

The interferogram reveals that the region on the base side of the slip line is at a higher level as compared to the region on the opposite side.

(ii) **Slip line on (111) face**

The interferogram on (111) face in figure 78.
(X 55) also reveals that the slip line on this face has the same morphology as the line observed on face (111). The measurements of the step height made at different places along the line are given in Table No. 8.2, and plot of step height against distance is shown in figure 81.

### TABLE NO. 8.2

<table>
<thead>
<tr>
<th>Distance from the edge in millimeters</th>
<th>Step height in Angstroms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1577</td>
<td>1225</td>
</tr>
<tr>
<td>0.4250</td>
<td>950</td>
</tr>
<tr>
<td>0.7287</td>
<td>640</td>
</tr>
<tr>
<td>0.8993</td>
<td>462</td>
</tr>
<tr>
<td>1.094</td>
<td>260</td>
</tr>
<tr>
<td>1.260</td>
<td>90</td>
</tr>
<tr>
<td>1.311</td>
<td>25</td>
</tr>
</tbody>
</table>

The graph is again a straight line. The angle between the two slipped regions comes out to be $1.07 \times 10^{-4}$ radians. It may be mentioned that in this case also the fringes
reveal that the region on the base side of the slip line is at a higher level as compared to the region on the apex side.

(iii) **Non-linear line on (111) face**

The interferogram on (111) face reveals that the non-linear line which runs right across the face and joins the two slip lines described above, shows a discontinuity in the level. The displacement of the fringes across the line is nearly the same everywhere suggesting a uniform slip right across the face. Examination of the (111) face of the crystal in polarised light revealed that the region towards the apex was strained.

8.3 **Discussion**

The mechanism of the formation of the slip can be explained as follows:

Since the regions on the apex side of the slip lines are at a lower level on both the faces, these portions of the crystal might have been subjected to compression at the points B and A from where the slips
initiate on the two faces. Such compression will lead to
(1) Production of slips on the two faces with the apex
regions at a lower level and (2) Slip may be produced on
(111) face joining the slip produced on the neighbouring
faces and this is what is actually observed.

Now the stress required to produce the slip
steps of 2080 Å and 1395 Å is $3.21 \times 10^9$ dynes/cm$^2$, assuming the Youngs modulus for diamond at room temper-
ature to be $10^{13}$ dynes/cm$^2$. This is much less than $1.4 \times$
$10^{11}$ dynes/cm$^2$ which is the stress necessary to break
carbon bonds and to produce a crack along the octahedral
surface. This is in confirmity with the observations that
the stress has produced slip and not cracks.

It is therefore concluded that:

(1) Crystallographic slip occurs in diamond.

(2) The slip lines may terminate in the middle of the
face and thus give rise to screw dislocations which
is in agreement with the spirals observed by Patel
and Ramachandran (1967) on octahedral faces.
(3) The magnitudes of the slips produced by the same stress may not be the same.