Application of Electron Channeling Contrast Image on Analysis of Dislocation Structures Induced by Indentation in Nickel Single Crystal

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Vickers indentation test is widely used mechanical test for observing the local strain field and evaluating the properties of metals [1-3]. However, the complex stress and strain field formed during the indentation will cause the uncertain values of hardness [3]. Investigation of strain field around the indent in the shape of square base is needed to comprehend the mechanism of deformation during indentation. In the early work, lots of researchers focus on the deformation pattern around the indent by comparison of simulation method and secondary electron microscopy within different crystal orientation. All of them indicated that the surface profile around the indent on the (001), (011), (111) oriented FCC single crystal revealed fourfold, twofold, and threefold symmetry, for the sake of dislocations emerge at the free surface and remain the line direction which is formed with the intersection of the slip plane and the surface plane [4-5]. J.-l. Zhang and S. Zaefferer also demonstrated that the line direction left on the surface is due to the dislocation loops intersect the surface. Furthermore, they calculated the dislocation density as a function of the distance to the indent center by counting the dislocation appeared on a surface. They found that the dislocation density is decreasing with increasing the distance to the indent center [6]. Above discussions, the characterizations of dislocation has not been defined directly around the indents. Therefore, in this study, the electron channeling contrast image (ECCI) technic is applied not only observes the near-surface defects but also identifies the dislocation type with invisible criteria.

The experimental material was pure nickel after 12 hours annealing at 1073K and then furnace cooling in order to eliminate the residual stress in the origin sample. In order to take ECC image the strain-free surface is require. After mechanical polishing, the sample was sent to ion mill under 5kV, 80 degree, and 5 minutes. The orientation mapping was done by EBSD to obtain the Euler angle (81, 113, 23) of selected grains in the purpose of reaching the channeling condition in SEM and gaining the ECC image. Figure 1 shows the deformation pattern around the indent which contain three slip traces. A, B, and C traces obtained from the Figure 2 which is corresponding to (-11-1), (111), and (11-1). According to the invisibility criteria, if the dislocation is screw type, there are more than two g vectors which make it invisible in the condition of $g \cdot b = 0$, and if the dislocation is edge type, there is only one g vector which make it invisible when $g \cdot b = 0$and $g \cdot u \times b = 0$. The experiment results shown in Figure 3(a) reveals the visible dislocation band at g= (-31-3). However, we found two g= (424) and g= (535) vectors made it invisible in Figure 3(b) and (c). Therefore, this dislocation band is the screw type. In the following experiment, we will identify the dislocation type of trace B and C. Furthermore, the activated slip system during the indentation test will also observed.

References

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<Figures>

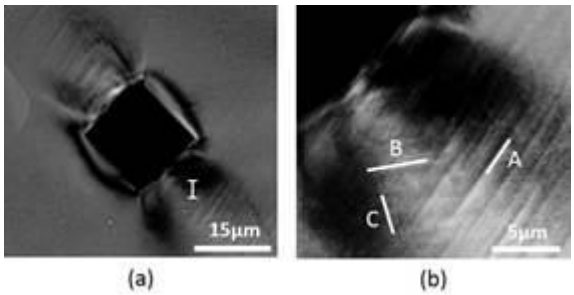

Figure 1. (a) The BSE image of the deformation pattern after doing the indentation test with 25gf loading. (b) Enlarged the area Ⅰ from (a), and there are three white line A, B and C indicated different slip plane trace.

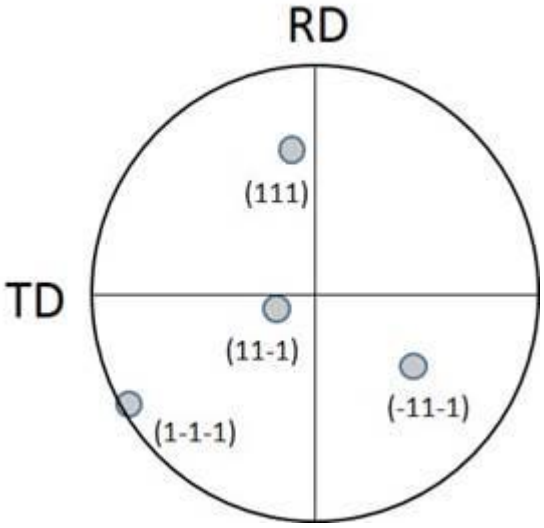

Figure 2. The (111) pole figure of single crystal Ni with Euler angle (81, 118, 23).

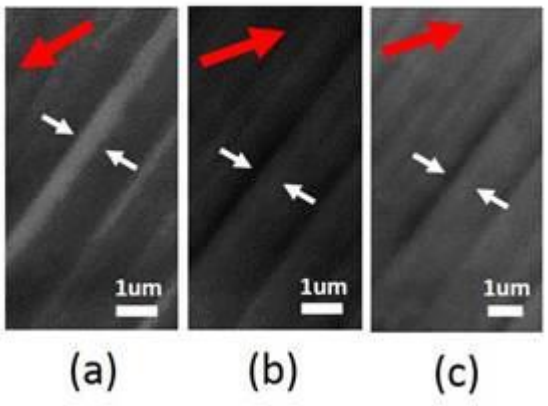

Figure 3. The ECC image of slip plane trace A corresponding to Fig. 1(b) with different g of (a) (-31-3), (b) (424), (c) (535). The white and red arrows are indicated slip traces and the direction of g vectors.

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