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Transmission-EBSD Using High Current Electron Beams

Majid Abbasi[1], Dong-Ik Kim[1], Hwan-Uk Guim[2] and Woo-Sang Jung[1]

[1.] High Temperature Energy Materials Research Center, Korea Institute of Science and Technology (KIST), Seoul 136-791, Republic of Korea
[2.] Nano-Bio Electron Microscopy Research Team, Korea Basic Science Institute (KBSI), Daejeon 305-333, Republic of Korea

majid.abbasi@kist.re.kr
Phone: (+82) 10-8946-8873
Fax: (+82) 2-958-5449

Transmission-EBSD (t-EBSD) also known as Transmitted Kikuchi Diffraction (TKD) is becoming increasingly popular among researchers in the field of nano/microstructure [1-6]. It offers a higher resolution than conventional EBSD while utilizing commercially available hardware and software. This enables large-scale quantitative measurements of nano- and ultra-fine-grained materials. However, recent studies have shown that severe drifting and carbon contamination may occur during the scanning of large areas with fine step sizes [6-7]. Additionally, it has been known that Kikuchi band intensity decreases significantly with increasing projection angle and detector distance from SEM's optical axis [7-9].

Utilizing high beam currents has been proposed to increase the intensity of Kikuchi bands, lower the detector exposure time, and enhance the acquisition speed leading to lower drifting and carbon contamination [6]. Despite the advantages of applying higher beam currents, an adverse effect on the spatial resolution is expected. The purpose of current research is to experimentally investigate the resolution on samples that have undergone lattice distortion and severe plastic deformation.

A single grain sample and a nano-grained sample were ion-implanted and studied to observe the effect of lattice distortion and severe plastic deformation on the pattern quality. Ion-implantation causes a change in lattice parameters and amorphization near the surface [10]. Pattern evolution with increasing lattice distortion as a result of Al ion-implantation on a Ni single grain is presented in Figure 1. Number of bands and identified Hough peaks decreases approaching the sample edge (see spots 1 to 5 in Fig. 1). Wider bands are observed approaching the ion-implanted area which indicates lattice expansion (compare patterns 3 and 4 with 1 and 2 in Fig. 1). No reliable well-defined patterns were obtained within the 300 nm depth which is consistent with the previous high resolution TEM study of ion-implanted samples [10]. This estimated depth of penetration was utilized to investigate the resolution of t-EBSD with high current beams in a severely deformed and Al ion-implanted surface of another Ni single grain sample (Figure 2).

Large pancaked grains become evident using a high beam current of 30 nA beneath the area affected by Al ion-implantation (Fig. 2b). Grains as fine as 30 nm are identified in this area. However, 30 nA beam current was unable to effectively reveal the grain structure of the area near the surface. A lower beam current (10 nA) proved successful in revealing the nano-grains near the surface (Fig. 2c). Grains as fine as 20 nm are identified. The fraction of non-indexed areas increases significantly in the zero to 400 nm depth due to grains being finer than t-EBSD resolution and amorphization observed in Fig. 1. Non-indexed areas appear as dark regions in Fig. 2c especially near the sample edge (surface). Further results addressing the effect of beam current on the pattern intensity, scanning speed, drift, and spatial resolution will be presented.

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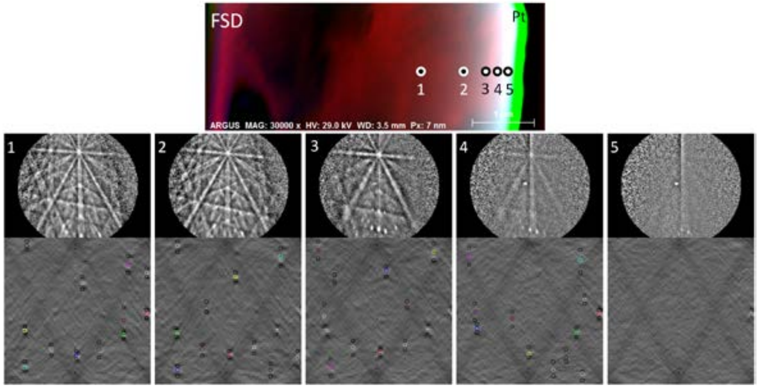

Figure 1. Pattern evolution with lattice distortion due to Al ion-implantation. Top: Forward Scatter Argus^{TM} Detector (FSD) image of an FIB slice from a Ni single grain. Bottom: Kikuchi patterns and identified Hough peaks (marked with dots). Bright diffraction spots appear at the bottom of patterns.

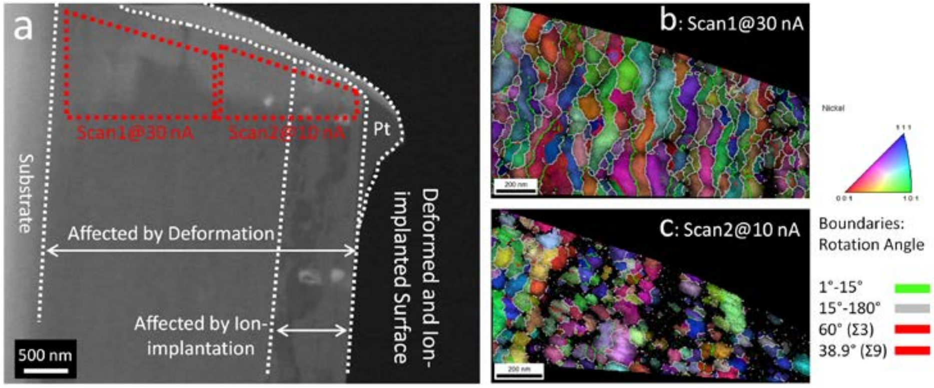

Figure 2. Applying high current electron beams to acquire fast low-drift scans. a) FIB slice of Ni single grain with severely deformed and Al ion-implanted surface. b) Grain structure of severely deformed area (Scan1) in (a) utilizing 30 nA beam current. b) Partial success in revealing the grain structure of severely deformed and ion-implanted area (Scan2) in (a) utilizing 10 nA beam current.