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Kernel Average Misorientation Confidence Index Correlation from FIB Sliced Ni-Fe-Cr alloy Surface

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Kernel average misorientation (KAM) during electron backscatter diffraction (EBSD) analysis can be used as a measure of local grain misorientation. KAM quantifies the average misorientation around a measurement point with respect to a defined set of nearest neighbor points. In this mode, the local misorientation assigned to the center point of a particular grain with respect to all points in the perimeter of the kernel are measured. Generally KAM is high in deformed grains due to higher dislocation density [1]. Because KAM analysis helps to understand local lattice distortions, localized deformation and high dislocation density, it may suggest stored strain energy in the grain. Recently, geometrically necessary dislocations in ultrafine dual phase steels were calculated based on KAM analysis [2]. The delaminating behavior of Al alloy was investigated using KAM [3]. A close relationship between harness values and KAM was also observed in stainless steel proving that KAM is effective tool for detecting creep damage [4]. Apart from KAM, in Orientation Imaging Microscopy (OIM) interface from EDAX/TSL, the term confidence index (CI) provides the quality of the backscatter diffraction patterns. CI is calculated using automated indexing of diffraction patterns from a ranking system, developed using the mechanism CI = $(V_1\text{-}V_2)/V_{ideal}$ where V_1 and V_2 are the number of votes for the first and second solutions and V_{ideal} is the total possible number of votes from the detected bands [5]. Therefore, ideal CI value from any given grain orientation is always one. In this work, a correlation is established between KAM and CI as a function of focused ion beam (FIB) slicing of Ni-Fe-Cr alloy surface. Due to the growing interest of Ni-Fe-Cr alloys in every metallic structures like spacecrafts, naval vessels, nuclear reactors and solid oxide fuel cell interconnects to tackle extreme environmental condition problems related to stress corrosion cracking, brittleness, oxidation behavior which influences its mechanical strengths, performing KAM-CI correlation experiments provide fundamental answers to address these challenges. Recent advances in 3D EBSD can also be used in-conjunction to get realistic information from a known bulk volume.

The images in Figure 1 show stacks of image quality (IQ) maps (top row), IQ & KAM overlapped maps (middle row) and IQ & CI overlapped maps (bottom row) recorded from 10'th, 30'th, 50'th, 70'th and 90'th slice of Ni-Fe-Cr alloy surface. A Ga-ion FIB source mounted on FEI Quanta 3D FEG dual-beam was used to create slices. EBS3 interface from FEI was used for the automated back and forth 180^0 rotation of Ni-Fe-Cr for a series of FIB slicing and EBSD mappings at normal to the slicing surface and 70^0, respectively. OIM interface from EDAX/TSL with Hikari high speed camera was utilized to collect EBSD data from 100 slices separated at 100 nm each. The ion and electron beam energies were 30 kV@3 nA and 30 kV @ 4 nA, respectively. The re-construction of the data in a 3D volume was done using OIM 3D view software. To preserve the originality, all of the data shown here represents raw and as collected data without performing any cleaning or post-processing. The dark lines in the IQ maps are grain boundaries. The darker shaded contoured region indicated by arrow, especially visible in the middle of top grain [(hkl=-3,34,10) (uvw=26,12,-33)], indicates lower IQ regions. By comparing IQ maps with KAM and CI maps, it is observed that same region also indicates higher KAM and lower CI values. As seen from the color coded scales for KAM and CI at the bottom, red and blue color contours overlap the low IQ regions. The higher KAM values observed near the grain boundaries are consistent with previous reports [2-4] indicating higher degree of misorientation. The images in Figure 2(a, b) are 100 slice 3D volume reconstruction of Ni-Fe-Cr surface where IQ & CI maps and IQ and inverse pole figure (IPF) maps are overlapped, respectively. The presence of 90 deg grain boundaries and twinning effects are also seen in the bulk volume. Because the IQ parameter is extremely sensitive to the surface preparation conditions, KAM cannot be used for quantitative analysis and can be only used qualitatively.

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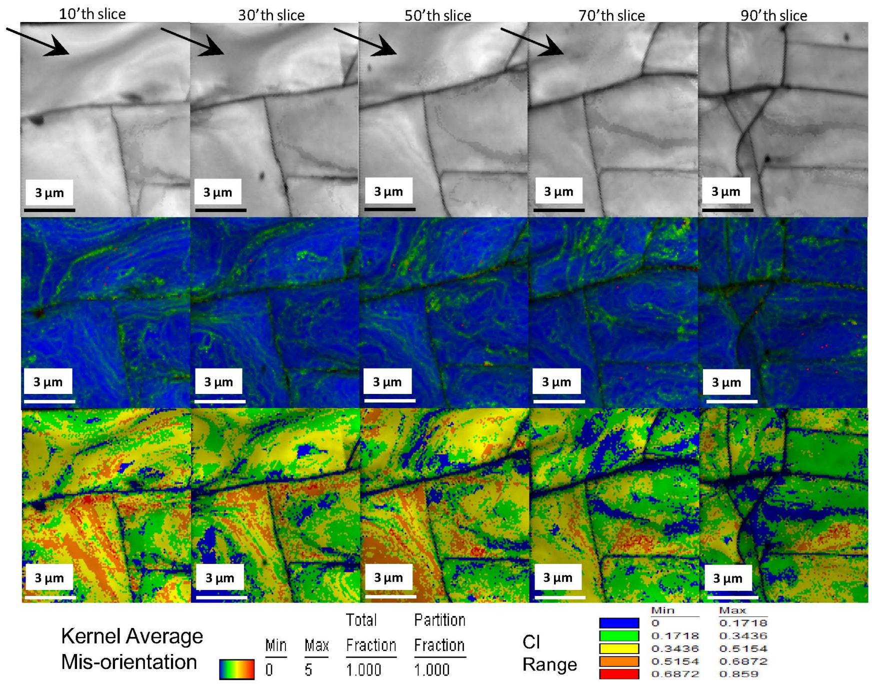

Figure 1 - Image quality (IQ) (top row), IQ & KAM (middle row) and IQ & CI overlapped maps (bottom row) recorded from 10'th, 30'th, 50'th, 70'th and 90'th slice of Ni-Fe-Cr alloy surface.

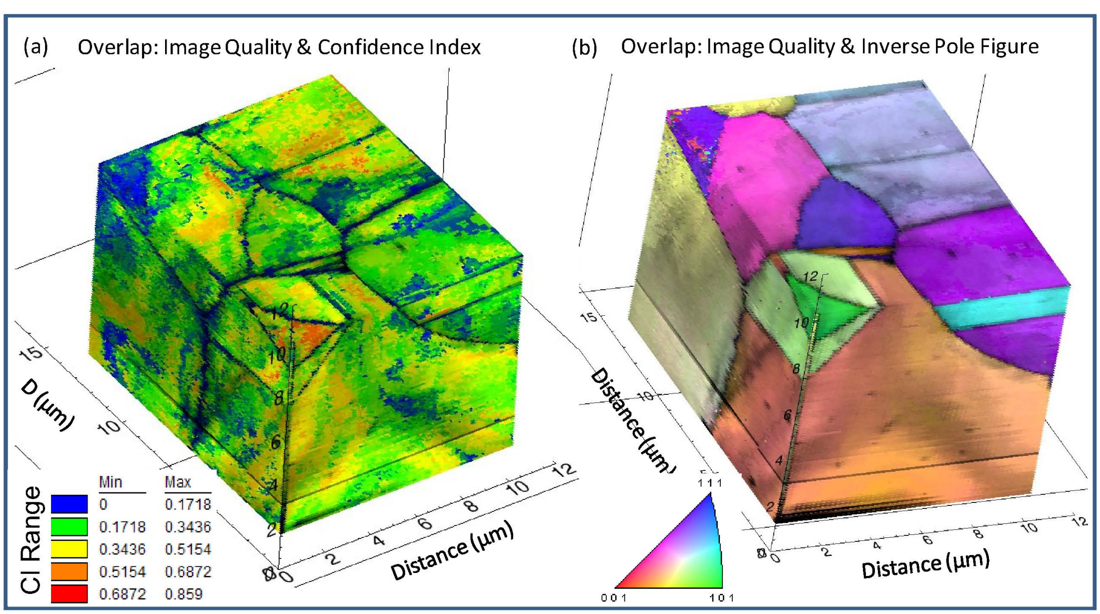

Figure 2 - 3D volume reconstruction from 100 FIB slices of Ni-Fe-Cr surface separated at 100 nm each.

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