1040 CD
DOI: 10.1017/S1431927606061040
Microsc Microanal 12(Supp 2), 2006

Recrystallization Behavior of ECAE Processed OFHC Copper

D. R. Waryoba and P. N. Kalu
FAMU-FSU College of Engineering, Tallahassee, FL 32310

Deformation texture and microstructure in Oxygen free high conducting (OFHC) copper rods, deformed by equal channel angular extrusion (ECAE) and annealed at 700°C, have been investigated by means of orientation imaging microscopy (OIM). The microtexture of the ECAE processed rods showed a transition from a deformation texture which was nearly random to a recrystallization texture composed of <111>//ED (ED – extrusion direction) fiber texture.

Equal channel angular extrusion (ECAE) is one of widely acceptable methods of severe plastic deformation (SPD) for producing ultrafine grain structures [1]. Deformation by ECAE is achieved by extruding a billet through two intersecting channels of equal cross-section. For a well lubricated billet, the material is subjected to a unidirectional simple shear deformation. Repeated passes impart very high strains without significant reduction in the cross-section area, resulting in various combinations of mechanical properties, grain size, and texture. Previous studies by the authors [2] on the annealing behavior of drawn OFHC copper showed abnormal grain growth when heavily drawn OFHC copper wires were annealed at about 700°C. The goal of this investigation was to study texture and microstructure development and stability in OFHC copper deformed by ECAE to 8 passes and annealed at 700°C. ECAE processing was performed at room temperature, using a 90° bend channel die, via route B_C (where the billet is rotated by 90° in the same direction between consecutive passes). The 90° bend die geometry results to an equivalent Von Mises strain of about 1 per pass [1]. Local orientations were mapped by means of OIM, automated electron backscatter diffraction (EBSD) technique in the scanning electron microscope (SEM).

Figure 1a presents OIM orientation map of the starting material. The map is shaded with lattice poles aligned parallel (//) to the rod axis (RA), according to the color coded key (inserted triangle). Thus, red colored areas have <100>//RA orientation and blue areas have <111>//RA orientation. Evidently, the microtexture of the starting material consisted of a strong<111>+ weak<100> duplex fiber texture, and the corresponding inverse pole figure (IPF) show a maximum intensity of 8.3. The average grain size (excluding twins) was 35 μm. Deforming to 1 pass, on the other hand, produced elongated grains which were 4 μm wide, and aligned in the shear direction (SD) as shown in Figure 1b. The grain orientation map, shaded with lattice poles parallel to extrusion direction (ED), showed a nearly random microtexture, and its IPF indicates a maximum intensity of 1.9. Figure 2a shows that further extrusion to 8 passes produced much finer elongated grains with an average grain thickness of about 1μm. However, some equiaxed, strain-free nucleating grains were also observed superimposed in the deformed microstructure. These grains were considered to have formed via dynamic recrystallization, a mechanism which has also been reported by Chang and co-workers [3] in ECAE processed OFHC copper. The overall microtexture of the deformed structure was random, with a maximum intensity of 1.6. Analysis of orientation of nucleating grains showed a random microtexture, suggesting that nucleating grains retained the microtexture of the deformed matrix.

On annealing at 700°C, a fully recrystallized microstructure with nearly equiaxed grains was formed. The grain size was about 57 μm, with a microtexture completely different from that of nucleating grains and deformed structure. Figure 2b shows a representative orientation map of the annealed microstructure, with a strong <111> fiber texture (maximum intensity of 7.3). Such a reversal in the texture has also been reported in drawn OFHC copper wires annealed at 750°C, and is attributable to thermal stability and high mobility of the <111> tilt boundaries [2]. A similar phenomenon has been reported by Park and Lee [4]

References

[1] Segal, V. M., *Mater. Sci. Eng*. **A197** (1995), 157-164.
[2] Waryoba, D. R., and Kalu, P. N., *Mater. Sci. Forum* **495-497** (2005), 877-882.
[3] W.H. Huang, C.Y. Yu, P.W. Kao, C.P. Chang, *Mater. Sci. Eng*. A366 (2004) 221–228
[4] H. Park and D. N. Lee, *Met. and Mater. Trans*., 34A (2003), 531.

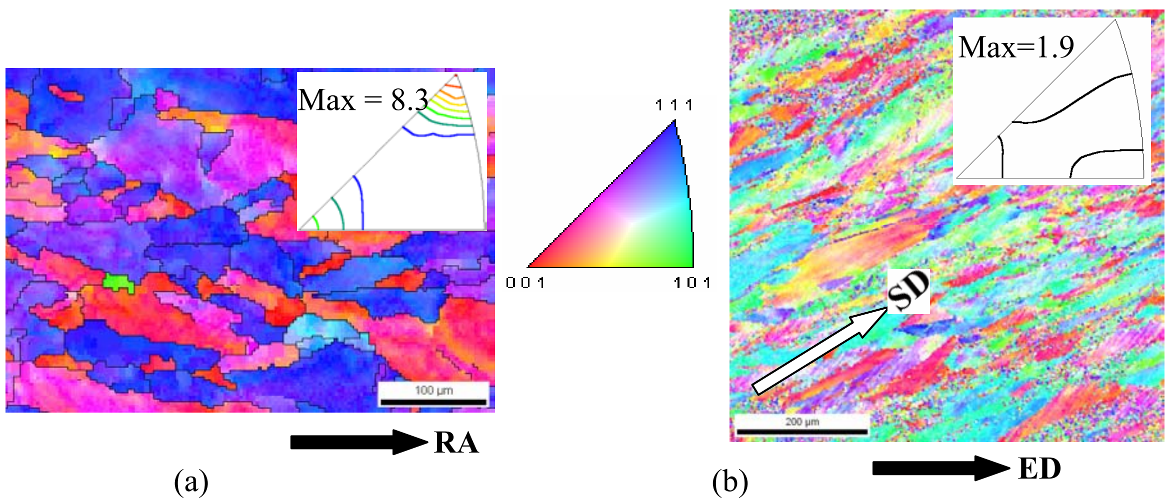

Figure 1 OIM orientation maps and IPFs showing microtexture of the (a) starting materials, and (b) after 1 pass of ECAE processing. Contours at 1, 2, 3, ... times random.

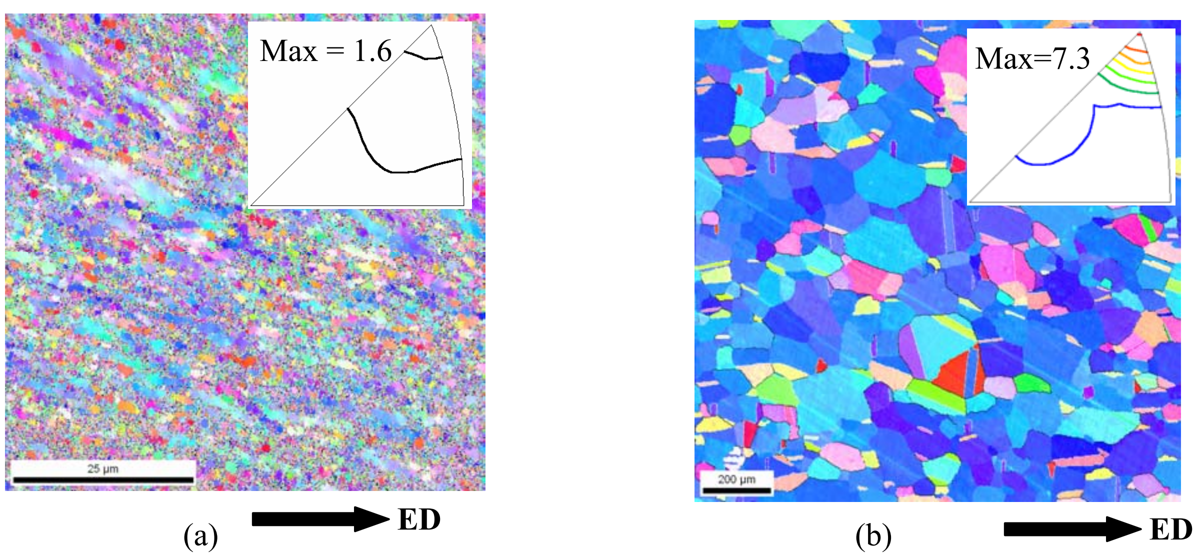

Figure 2 OIM orientation maps and IPFs showing microtexture of (a) ECAE copper processed to 8 passes and (b) subsequently annealed at 700°C. Contours at 1, 2, 3, ... times random.

https://doi.org/10.1017/S1431927606068632 Published online by Cambridge University Press