Microstructural Characterization Of Aluminum Alloy AA1050 With Ultrafine Structure Obtained By Intense Plastic Deformation (ECAP).

M. C. L. Guerra[1], W. A. Monteiro[1, 2,*], N. A. M. Ferreira[2] , L. C. E. Silva[2]

[1] Escola de Engenharia, Universidade Presbiteriana Mackenzie, São Paulo, SP
[2] Centro de Ciências e Tecnologia de Materiais – IPEN, São Paulo, SP
wamontei@ipen.br

This paper presents microstructures related to optical microscopy (OM), scanning electron microscopy (JEOL-JSM6510), and transmission electron microscopy (JEOLJEM2010) in specimens (aluminum AA1050 alloy) subjected to four processing passes using a two-part mold (D2 tool steel) with two rectangular channels of equal cross sections intersecting at an angle (Φ) of 120° to each other and with external elbow angle (ψ) of 60°, using two different ECAP routes, A (no changing in the direction of the specimen after each applied pass) and B_C (the specimen is turned 90° in the same direction in relation to the longitudinal axis after each pass). The chemical composition is: 0.34 w% Fe; 0.18 w% Si; 0.04 w% Mg; 0.01w% Mn; 0.01 w% Cu (CBA/SP, Brazil). Previously the ECAP, the specimens were heat treated at 673K during 1800s, followed by cold water quenching, and finally surface-polished using 1200 grit SiC paper. Considering the deformation process condition the heterogeneity in microstructure formation was often observed across the bulk specimen in dependence of the introduced strain (Figures 1 - 5). As results of different applied straining the banded elongated subgrain structure is present due to dominant shear strain. With increasing deformation, a part of the dislocations was absorbed by subboundaries and increased the misorientation among the subboundaries changing into boundaries of low and high angle and contributes to a substantial number of activated slip planes of the same family [1 - 3]. The literature also indicates that these microtwins can act as new grains nuclei due to the: (a) generation of a high density of dislocations within the microtwins; (b) subsequent formation of deformation groups on interior of the microtwins (Figure 5.a). Initially, dislocations can pile-up near the walls of the microtwins giving possibility to produce new grain nuclei and also some atomic planes during rotation process divided the existing microtwins, producing new nano domains with a possible ultrafine grains formation [2, 3]. The multiple deformations of the microtwins accommodating of applied plastic deformation and the presence of second phases (mostly, θ-Al_2Cu and Al_{13} Fe_4) contribute to the ultra-fine grains mechanisms [1 - 4]. Regarding the microstructural observation (Figs. 2 - 5) of AA1050 Al alloy exposed to the ECAP procedure (A and Bc routes) it can be concluded that the intense deformation process produces a microstructural variation with respect to the size of the grains obtained after ECAE process.

Reference

[1] R.Z. Valiev, T.G. Langdon, Rev. Adv. Mater. Sci. 13 (2006) 15-26
[2] M.R. Shankar et al., Scr. Mater. 58, (2008) pp. 675-678.

[3] J.C. Villegas et al., Mat. Sci. Eng. A 410–411 (2005), pp. 257–260.
[4] Z.K. Liu, Y. A. Chang, Met. Mat. Trans A, v. 30A, (April 1999), pp. 1081-1095.
[5] This research was supported by CNPq and Mackpesquisa (Mackenzie Presbyterian University) (Brazil).

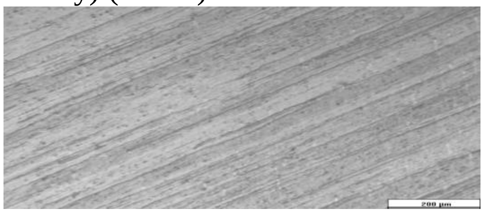


Figure 1- Optical micrograph of as received AA1050 Al; Elongated grains band. (Scale: 200µm).

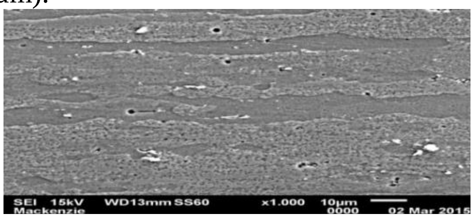
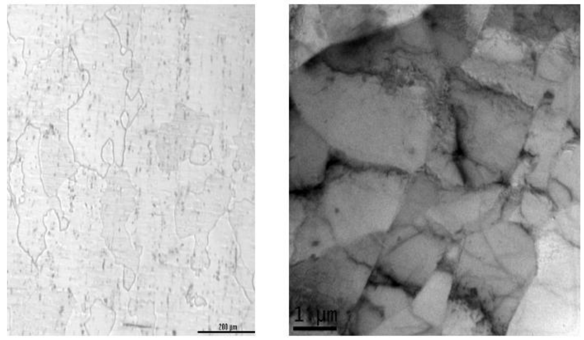
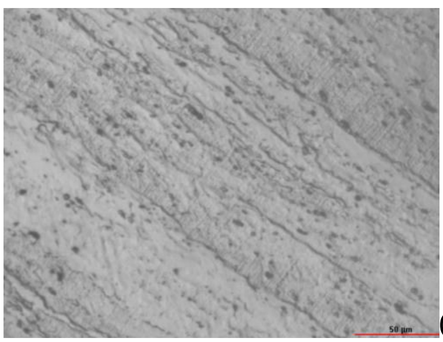


Figure 2- Scanning electron micrograph of as received AA1050 Al; Presence of precipitates. (Scale: 10 µm).

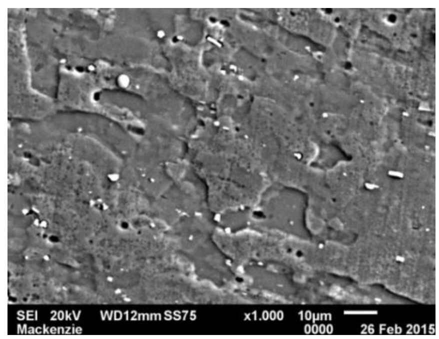


(a) (b)

Figure 3- Micrographs: (a) Optical (OM, scale: 200µm); (b) Electron (TEM, scale: 1µm) of AA1050 alloy heat treated ($400^{o}C$/1800s); grains growth and presence of fine precipitates (θ-Al_2Cu and $Al_{13}Fe_4$).

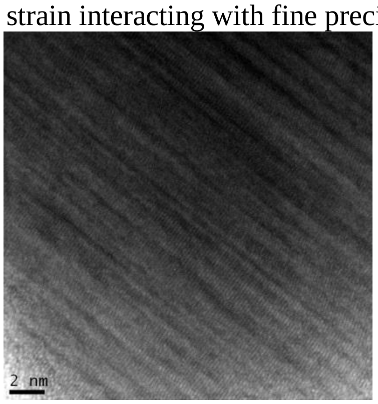


(a)

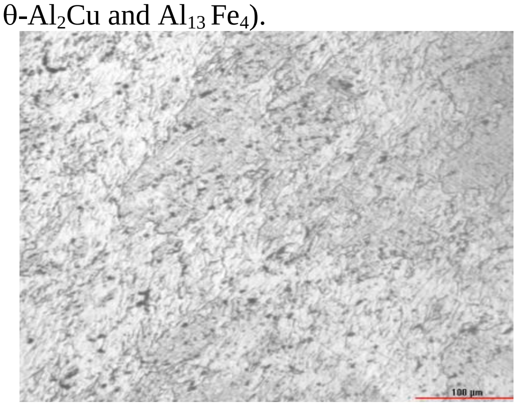


(b)

Figures 4- Optical and scanning electron micrographs of AA1050 Al alloy heat treated at $400^{O}C$ for 30 min and processed by route A (4 passes); banded elongated subgrain structure due to dominant shear strain interacting with fine precipitates (almost θ-Al_2Cu and $Al_{13}Fe_4$).



(a)



(b)

Figures 5- Micrographs of AA1050 aluminum alloy heat treated at $400^{O}C$ for 30 min and processed by route Bc (4 passes). (a) TEM - presence of microtwins; (b) OM – grains and subgrains structure due to dominant shear strain (ECAP) also interacting with fine precipitates (scale: 100µm).