Evolution of dislocations and texture in cold-rolled and annealed aluminum alloys

Jurij J. Sidor[a], Purnima Chakravarty[b], János Gy. Bátorfi[a,b], Gyula Pál[a,b]

[a]*Savaria Institute of Technology, Faculty of Informatics, Eötvös Loránd University, Károlyi Gáspár tér 4, Szombathely, 9700-Hungary*

[b]*Doctoral School of Physics, Faculty of Natural Sciences, Eötvös Loránd University (ELTE), P.O. Box 32, Budapest, 1518-Hungary*

[a]*e-mail address of corresponding author js@inf.elte.hu*

This contribution analyses the development of crystallographic texture and dislocation density in Al alloys deformed with different straining levels. The correlation between the pre-deformation state, deformed and annealed counterparts is examined. To characterize the deformed state, a variety of techniques such as microindentation, X-ray diffraction line profile analysis [1] as well as electron backscattering diffraction were employed. These experimental methods allowed tracing the crystallographic aspect of microstructure evolution as well as assessing the evolution of dislocation density in the deformed materials. The investigated materials were exposed to deformation levels ranging between 0.06 and 1.7, which has resulted in a continuous increase in the dislocation density. The results gained suggest that even a small straining of 0.06 accounted for the substantial evolution of dislocation density above 10^{13} m^{-2} while the straining level above 0.3 has led to the density of dislocations of ~10^{14} m^{-2}. The experimentally measured pattern of the development of dislocation density was accurately reproduced by numerical models [2, 3] for the low, moderate, and high deformation levels. The evolution of crystallographic texture in the deformed and subsequently recrystallized materials was examined by experimental and modeling approaches. The employed finite element, flow line [4], and crystal plasticity models enabled an explanation of the heterogeneous nature of texture evolution across the thickness of rolled sheets, while the texture development in the recrystallized samples was explained by employing basic principles of crystal plasticity and grain growth selection criteria. This contribution shows that the pre-rolling state has a great influence on the development of annealing texture and plastic strain ratio in Al alloys.

Keywords: deformation, texture, dislocation density, modeling.

Acknowledgment:

This research was carried out within project no. TKP2021-NVA-29. The financial support is provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development, and Innovation Fund. The work is financed under the TKP2021-NVA funding scheme.

References:

[1] Gubicza, J., Ungár, T. Characterization of defect structures in nanocrystalline materials by x-ray line profile analysis, Z. Kristallographie, 222, 2007, 567–579.
[2] Kubin, L.P., Estrin, Y. Evolution of dislocation densities and the critical conditions for the Portevin-Le Chatelier effect, Acta Metall. Mater., 38, 1990, 697–708.
[3] Csanádi, T., Chinh, N.Q., Gubicza, J., Vörös, G., Langdon, T.G. Characterization of stress–strain relationships in Al over a wide range of testing temperatures, Int. J. Plast., 54, 2014, 178–192.
[4] Sidor, J.J. Assessment of Flow-Line Model in Rolling Texture Simulations, Metals, 9, 2019, 1098.