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DEFORMATION-INDUCED MICROSTRUCTURAL EVOLUTION AT GRAIN SCALE

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During plastic deformation metals develop microstructures which may be analysed on several scales, spanning from crystallographic textures averaged over the entire sample to the scale of individual grains. Even within individual grains, intragranular phenomena in the form of orientation gradients as well as dislocation patterning by formation of dislocation boundaries occur. Experimental data and associated data analysis at the grain scale and below will be presented to illustrate our current level of understanding. The basis for the analysis is the crystallographic orientation of the grain as well as the slip systems that are activated.

More specifically the origin of both inter- and intragranular orientation spread is analysed for a specific example from tensile deformed interstitial-free steel [Oddershede et al. 2015]. A universal framework for the patterns consisting of dislocation boundaries is presented for both fcc and bcc materials in several deformation modes, demonstrating a clear grain orientation dependence [Huang & Winther, 2007]. This dependence has its origin in a dependence on the slip systems [Winther & Huang, 2007]. This further implies that the dislocations in the boundaries come from the active slip systems, which is confirmed by experimental data [McCabe et al. 2004; Wei et al., 2011; Hong, Huang, & Winther, 2013]. The elastic interactions between these dislocations are the driving force for the patterning [McCabe et al. 2004; Wei et al., 2011; Winther, Huang & Hong 2015]. The current state of understanding as well as the major outstanding challenges are discussed.

REFERENCES:

Hong, C.S., Huang, X., & Winther, G., 2013, “Dislocation content of geometrically necessary boundaries aligned with slip planes in rolled aluminium”, Philosophical Magazine, **93**(23), 3118–3141.

Huang, X., & Winther, G., 2007, “Dislocation structures. Part I. Grain orientation dependence”, Philosophical Magazine **87**(33), 5189–5214.

McCabe, R. J., Misra, A., & Mitchell, T. E., 2004, “Experimentally determined content of a geometrically necessary dislocation boundary in copper”, Acta Materialia **52**(3), 705–714.

Oddershede, J., Wright, J. P., Beaudoin, A.& Winther, G, in press, “Deformation-induced orientation spread in individual bulk grains of interstitial-free steel”; Acta Materialia.

Wei, Y. L., Godfrey, A., Liu, W., Liu, Q., Huang, X., Hansen, N., & Winther, G., 2011, “Dislocations, boundaries and slip systems in cube grains of rolled aluminium”, Scripta Materialia **65**(4), 355–358.

Winther, G., & Huang, X., 2007, “Dislocation structures. Part II. Slip system dependence”, Philosophical Magazine **87**(33), 5215–5235.

Winther, G., Hong, C.S., & Huang, X., 2015, “Low-energy dislocation structure (LEDS) character of dislocation boundaries aligned with slip planes in rolled aluminium”, Phil. Mag. (in print).