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Publication date:
2016

Document Version
Peer reviewed version

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A recent study [1] has shown that a microstructure can be refined to a record low of 5 nm and that dislocation glide is still a controlling mechanism at this length scale. The nanostructure was produced in Cu by applying a very high strain in friction. The stress and strain decrease with increasing distance from the surface forming a gradient structure. In this study [2], by shot peening of a low carbon steel a gradient structure has been produced extending to about 1 mm below the surface. A number of strengthening mechanisms have been analyzed as a basis for a calculation of the stress and strain as a function of the distance from the surface. The results are evaluated by a finite element investigation of shot peening.

[1] D. A. Hughes and N. Hansen, Exploring the Limit of Dislocation Based Plasticity in Nanostructured Metals, PRL 112, 135504 (2014).

[2] X. Zhang, N. Hansen, Y. Gao, X. Huang, Hall–Petch and dislocation strengthening in graded nanostructured steel, Acta mater. 60, 5933-43 (2012).