Additivity of Strengthening Mechanisms in Severe Plastically Deformed Metals and Alloys

Soumita Mondal[a], Shavi Agrawal[a], Surendra Kumar Makineni[a], Pradipta Ghosh[b], Satyam Suwas[a]

[a] *Indian Institute of Science, Bangalore, 560012, India*
[b] *Indian Institute of Technology, Gandhinagar, 382355 India*
[a] *satyamsuwas@iisc.ac.in*

Pure Nb, Nb-1Zr and Nb-1Zr-0.1C (wt.%) were subjected to high-pressure torsion deformation for producing bulk nanocrystalline microstructure. Microstructural features obtained from SEM-EBSD showed negligible variation with alloying additions, unlike the dislocation density and its arrangements obtained by X-ray line profile analysis by Convolutional Multiple Whole Profile fitting. Flow stresses evaluated by Tabor's relation from the Vicker's microhardness testing showed a remarkable increment from 732±18 MPa in pure Nb to 925±44 MPa in NZC at strain 70. Since microstructural features exhibited similarities, the deformed microstructural constituents were probed using the Atom Probe Tomography. The results obtained enabled the deconvolution of the strengthening contributions from Peierls stress, Hall-Petch hardening, Taylor hardening, solid solution strengthening and precipitation strengthening. Fitting of the theoretically calculated strengthening contributions to the experimental data enabled the deduction of a non-linear additivity rule that attributed the predominant strengthening contribution to come from the high density of severe plastically induced dislocations. Results were also correlated with previous works on Al-Mg and Cp-Ti.

Keywords: Niobium alloys, Severe Plastic Deformation, APT, CMWP, Strengthening mixture

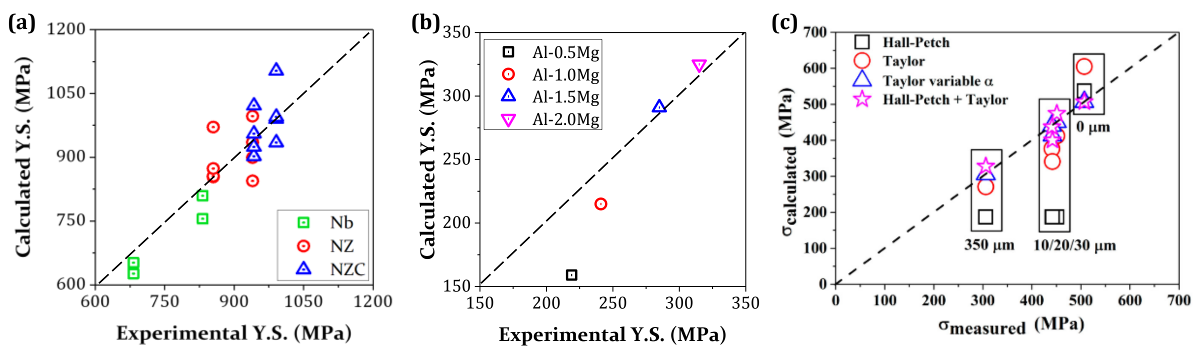

Fig.1: Experimentally measured Y.S. vs theoretically calculated Y.S. by linear / non-linear additive rules for (a) Nb alloys, (b) Al-Mg alloys, and (c) cp-Ti.

References:

[1] Sumit Bahl, Bhavya Tulasi Aleti, Satyam Suwas, Kaushik Chatterjee, Establishing the microstructure-strengthening correlation in severely deformed surface of titanium, Philosophical Magazine, 98, 2018, 2095-2119.
[2] R.Kalsar, D.Yadav, A.Sharma, H.G. Brokmeier, J.May, H.W.Höppel, W.Skrotzki, S.Suwas, Effect of Mg content on microstructure, texture and strength of severely equal channel angular pressed aluminium-magnesium alloys, Materials Science and Engineering A, 797, 2020, 140088