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Alloy chemistry and size effect: A micromechanical study of fcc high entropy alloys

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In the present work we use in-situ SEM micro pillar testing to investigate the mechanical strength and the intensity of the size effect in binary, ternary, quaternary and quinery equiatomic alloys. We combine ingot metallurgy with orientation imaging electron microscopy to select grains in single slip orientation for micro pillar focused ion beam (FIB) micro machining.

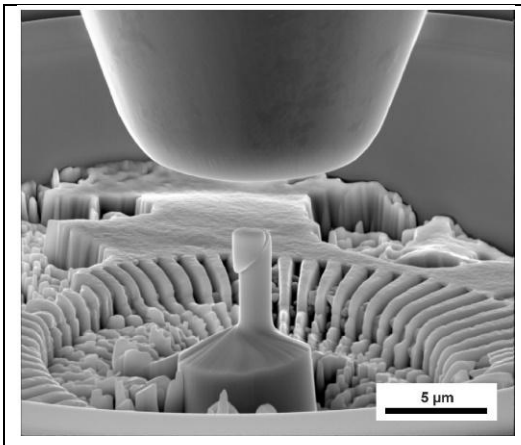

Fig. 1: SEM image of a high entropy micro pillar single crystal oriented for single slip after compression loading.

Special emphasis was placed on precise geometries and on reproducible stress states. Around 130 micro mechanical tests were performed on cylindrical micro pillars with diameters of 1.5, 4 and 8 µm. A total of 8 equiatomic alloys were considered (CoNi, FeNi, CrCoNi, FeCoNi, MnCoNi, MnFeNi, CrFeCoNi, CrMnFeCoNi). In all alloys critical resolved shear stresses (CRSSs) were obtained by extrapolating the micro pillar data to micro pillar diameters of 20 µm. CRSSs decreased with increasing pillar size and the sensitivity of the effect decreased with increasing pillar strength. The results obtained in the present work clearly show that a higher entropy of mixture does not directly lead to higher strength.

Keywords: High entropy alloys, mechanical behavior, in-situ SEM, micro pillar testing, deformation mechanisms