

Anomalous High Strain Rate Compressive Behaviour of Additively Manufactured Copper Micropillars

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Microscale dynamic testing is vital to the understanding of material behaviour at application relevant strain rates (SR). However, despite two decades of intense micromechanics research, the testing of microscale metals has been largely limited to quasi-static strain rates. Here we report the dynamic compression testing of pristine 3D printed copper micropillars at SRs from $\sim 0.001 \text{ s}^{-1}$ to $\sim 500 \text{ s}^{-1}$. It was identified that microcrystalline (MC) copper micropillars deform in a single-shear like manner exhibiting a weak SR dependency at all strain rates. Ultrafine grained (UFG) copper micropillars, however, deform homogenously via barrelling and show strong rate-dependence and small activation volumes at SRs up to $\sim 0.1 \text{ s}^{-1}$, suggesting dislocation nucleation as the deformation mechanism. At higher SRs, yield stress saturates remarkably, resulting in a decrease of SR sensitivity by two orders of magnitude and a four-fold increase in activation volume, implying a transition in deformation mechanism to collective dislocation nucleation [1].

Keywords: additive manufacturing, 3D printing, micromechanics, high strain rate testing, microstructural characterization

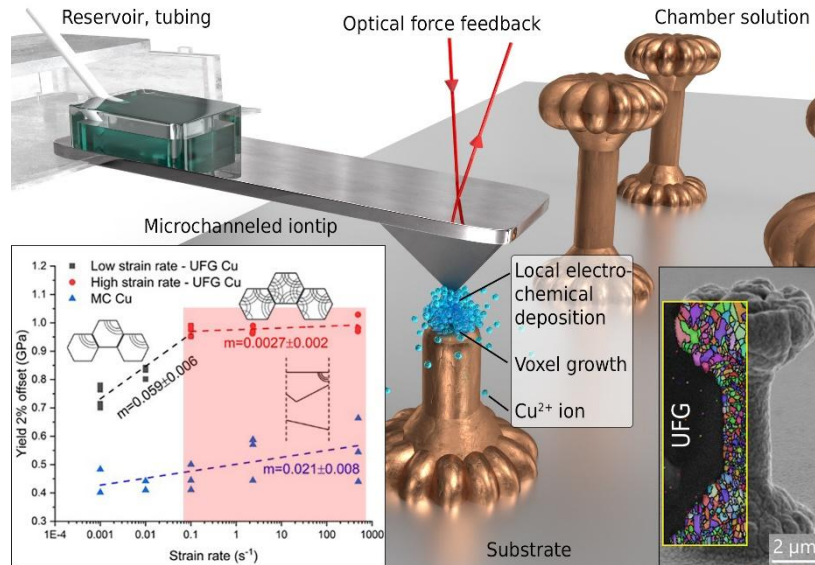


Fig.1. Printing process and SR sensitivity of compressed micropillars with various initial microstructure.

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References:

- [1] S. Kalacska, R. Ramachandramoorthy, G. Poras, J. Schwiedrzik, T.E.J. Edwards, X. Maeder, T. Merle, G. Ercolano, W.W. Koelmans, J. Michler, Anomalous High Strain Rate Compressive Behavior of Additively Manufactured Copper Micropillars. *Applied Materials Today*, (2022) in press. URL: <https://arxiv.org/abs/2201.01582>