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Synthesis and Mechanical Response of Colloidal Micropillars[1]

DANIEL STRICKLAND, University of Pennsylvania, LEI ZHANG, University of Alaska Fairbanks, YUN-RU HUANG, DAEYEON LEE, DANIEL GIANOLA, University of Pennsylvania — We present a new approach for studying the uniaxial compressive behavior of colloidal micropillars as a function of structural order/disorder, pillar and colloid dimension, and interparticle interaction. By varying the polydispersity of the particles, ordered packing may be promoted or suppressed, leading to the formation of crystalline or amorphous pillars. Pillars composed of nanometer scale particles develop cracks during drying, while pillars composed of micron scale particles dry crack-free. We subject the pillars, with diameters ranging from 300μm to 1mm, to uniaxial compression experiments using a custom-built micromechanical testing apparatus. In pillars with pre-existing cracks, compression activates the macroscopic defects, leading to fracture and stochastic mechanical response as a result of the flaw distribution. Pillars that dry crack-free fail by shear bands that develop near the punch face. While macroscopically identical, pillar-to-pillar mechanical response varies significantly. We rationalize the difference in behavior as a result of varying structure and environmental conditions. Specifically, the level of atmospheric humidity significantly affects particle-particle cohesion and friction, resulting in dramatically different mechanical response. We discuss the results in the context of underlying particle rearrangements leading to mesoscopic shear localization and examine comparisons with atomic disordered systems such as metallic glasses.

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