Using Shape Anisotropy to Toughen Disordered Particle Packings

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Abstract: Disordered solids constitute an important class of materials that find wide-ranging applications from energy devices to bone replacement. However, a major roadblock limiting the widespread utilization of these materials is their tendency to undergo mechanical failure under small load. The fundamental understanding on their mechanical behavior is imperative for the development of new strategies to enhance their mechanical properties (*hardness*, *modulus*, and *fracture toughness*). In our work, we fabricate disordered nanoparticle packings by using TiO_2 prolate nanoellipsoids with various aspect ratios and investigate their mechanical properties using nanoindentation. We observe striking similarities in the deformation mechanism of disordered nanoparticle assemblies to that of metallic glasses, which are random packings of metallic atoms. It is demonstrated that anisotropic nanoparticles greatly suppress shear band formation and toughen nanoparticle packings without sacrificing their strength, which implies that tuning constituent-anisotropy would be a new strategy to enhance toughness in disordered solids.