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Size and Shape Effects on the Strength of Platinum Nanoparticles

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Mechanical properties of nanoparticles have received a great deal of attention due to growing interest in their applications. In particular, the applications of nanoparticles in energy storage and conversion, polishing, finishing and strain-engineered catalysis require deep knowledge of their mechanical properties. We have studied the compressive strength of Pt nanoparticles of widely varying shapes and sizes produced by the solid-state dewetting method, and report a maximum compressive strength of 9.5 GPa. This strength approached the lower limit of the theoretical strength of bulk Pt, yet in relative terms it is far lower than the strength of the particles of other face centered cubic metals, Au and Ni, fabricated using the same solid-state dewetting method. We report a clear size effect on strength – as reported in previous research – along with a novel shape effect. We formulated a combined power law describing the dependence of particles strength on their size and shape in terms of geometrical parameters which are easily accessible experimentally. Our experimental results are in a good agreement with previous computational studies on the strength of Pt.

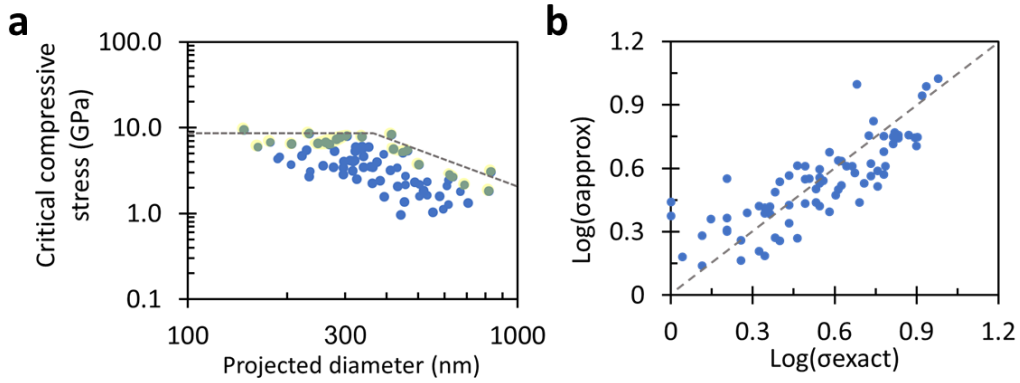

Fig. 1 Shape and size dependencies of the particle strength, σ. **a** Size dependence of strength. A change of trend in the top envelope (marked in yellow) of the strength is noted at 400 nm projected diameter. **b** Correlation between the experimentally measured strength and predictions of a size-shape equation.