Deformation in Small Metal Volumes - the Role of Length Scale

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It is well known that small metal volumes exhibit much higher strengths than their bulk counterparts.

This fact allows sub-micrometer metal components, such as the thin films or interconnects found in microelectronic devices, to be used reliably under extreme conditions. However, the atomic scale mechanisms associated with the increased strength are not entirely understood. Particularly in the sub-100 nm length scale regime, the origin of the high strength is not clear. In this presentation, a variety of micromechanical testing methods – including in-situ electron microscopy – have been applied to nanoporous Au foam specimens and single crystal Au whiskers in an effort to correlate strength with deformation mechanisms. It is observed that the deformation mechanism changes from one dominated by full dislocations to one controlled by partial dislocations as the characteristic size of the specimens is decreased below approximately 150 nm. Possible explanations for how this change in mechanism can account for high strengths will be discussed.

This work highlights an important scientific issue : how the transition from individual to collective behaviour of dislocations occurs at the nanometer length scale.