SHOCK19-2019-000067

Abstract for an Invited Paper
for the SHOCK19 Meeting of
the American Physical Society

Structure-Property Relationships at the Extremes

CYRIL WILLIAMS, US Army Rsch Lab - Aberdeen

The inelastic response and mechanical properties acquired from most shock compressed solids are distinctly different from those acquired from quasi-static or moderate strain rates. For instance, the residual hardness of many shock compressed metals has been found to be considerably lower than those loaded under quasi-static conditions to the same maximum stress. However, the residual hardness of shock compressed metals is much higher than those loaded quasi-statically to the same total strain. These observations suggest that the mechanisms active during inelastic deformation under shock compression and quasi-static or moderate rates may be quite different. This talk concerns the dynamic response of metals and metallic alloys at the extremes. Results derived from shock recovery experiments show that the as-received microstructure and how it evolves can strongly influence the mechanical response and consequent failure of metals and metallic alloys. The failure characteristics in 1100 aluminum changes from ductile to quasi-brittle at 8.3 GPa perhaps due to dynamic recovery. Failure in both 5083 aluminum and AZ31B magnesium was determined to be dominated by heterogeneous nucleation, growth, and coalescence of micro-voids from large second phase intermetallic inclusions. However, isolated regions of nano-voids were observed which were attributed to homogeneous nucleation (possibly from vacancies/vacancy clusters), growth and coalescence. The failure characteristics in UFG AMX602 magnesium was distinctly different from the aforementioned materials. Failure did not initiate from large intermetallic inclusions because there were none present in AMX602 magnesium. However, numerous isolated cracks were observed around the spall plane and the fracture surface was found to be striated due to the formation of oxide layers during the powder metallurgy process. Also, time-resolved in-situ XRD shock experiments show twinning during compression and detwinning during stress release. The microstructure and residual hardness of nanocrystalline Cu-Ta alloy proves to be insensitive to shock stresses ranging up to 15 GPa. These findings warrant more research to develop a better understanding of the role of microstructure in shock compressed solids.