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Substructure Evolution in a Shock Loaded [100] Aluminum Single Crystal

G.T. (Rusty) Gray III, Calvin Lear, Carl P. Trujillo, Ginny Euser

[a]*Los Alamos National Laboratory, MailStop G755, Los Alamos, NM, USA*

[a]*rusty@lanl.gov*

Interest in the shock-loading response of aluminum(Al) dates to the early seminal study of John S. Rinehart in 1955[1]. Since that time numerous researchers have probed the substructure evolution in shock-loaded single and polycrystalline Al[2]. Unlike many other face-centered-cubic pure metals, such as Cu and Ni, these studies have documented the absence of shock-induced twinning in poycrystalline Al even when Al is shock loaded to high peak shock stresses and at low temperature[2]. More recent research on a Cu single crystal[3] has demonstrated the strong influence of crystal orientation on the peak shock stress required to initiate deformation twinning in high-purity Cu. Coincident with this finding, research by Brown et. Al. [4] has demonstrated a technique by which converging shocks in bi-material concentric shock assembly can be utilized to develop a Mach conical converging shockwave leading to high shock pressures. In the current study, a [100] high purity Al single crystal was shock loaded in a target assembly comprised of three machined pieces, the sample a [100] oriented Al single crystal and two surrounding concentric tantalum rings. A 3.94mm thick tantalum flyer plate was accelerated and impacted target assembly at 455 m/s at -165C. Due to this experimental configuration the stress path in the [100] Al single crystal starts at 5.7 GPa in the Al but transitions to the peak stress state given by the Ta impactor hitting the Ta ring surrounding the Al crystal at the impact velocity which is ~ 14 GPa. The central [100] Al crystal cylinder thereafter rings up via lateral Mach waves such that the Al crystal sees a complex biaxial strain field across the Al crystal and higher shear stresses. In this talk the substructure evolution in the [100] Al single crystal will be presented, including twinning, and discussed in relation to previous data on the substructure evolution in polycrystalline Al.

Keywords: Shock Loading, Aluminum, Shock Recovery, Mach Waves, Twinning

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