Microstructures in Gas-Atomized and Cold-Sprayed Al6061 Powder

Benjamin Bedard[1], Alexis Ernst[1], Avinash M. Dongare[1], Seok-Woo Lee[1], Harold D. Brody[1], Aaron Nardi[2], Victor K. Champagne Jr.[3], Mark Aindow[1]

1. Materials Science and Engineering, and Institute of Materials Science, University of Connecticut, Storrs, CT
2. United Technologies Research Center, 411 Silver Lane, East Hartford, CT 06108
3. U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Aberdeen Proving Ground, Aberdeen, MD.

In the cold gas dynamic spray (CGDS) process, solid powder particles are entrained in a supersonic gas stream. When these particles impinge upon a substrate, they undergo severe plastic deformation and localized adiabatic heating. For impacts above a critical particle velocity, these processes lead to interfacial shear instabilities and to the formation of strong bonds between the powder particles and the substrate [1-4]. One of the alloys that has been used most frequently for CGDS is Al 6061, which contains Mg and Si as the main alloying additions. Al 6061 is a heat-treatable system whose properties are controlled by the morphology and distribution of Mg_2Si precipitates. Substrates of Al 6061 in the T6 condition are a common choice for CGDS spray trials with Al-based powders. Gas-atomized Al 6061 powders have also been used in CGDS to deposit alloy and composite coatings, for structural repairs of damaged or worn surfaces, and to deposit interlayers for the joining of Al to Mg alloys.

In this study, a combination of electron microscopy techniques is used to investigate the internal microstructure of gas-atomized Al6061 powders in the as-atomized, heat-treated and homogenized conditions, and CGDS deposits of these powders. Figure 1a shows as-atomized powder particles mounted using colloidal graphite. Figure 1b is a higher magnification image of a typical powder particle, revealing a rippled surface and the presence of small satellite particles adhered to the main powder particle. Figures 1c-e are BSE images of metallographically cross-sectioned powders embedded in epoxy for each powder condition. These images reveal an internal microstructure comprised of many 2-5 μm "cells", defined by the presence of microconstituents at their boundaries. Channeling contrast shown in the Plasma FIB cross-sections in Figures 1f-h demonstrates that each grain is comprised of several cells. This contrast also shows the reduced effect of grain boundary pinning in the homogenized powder as a result of dissolution and coarsening of secondary phases. Figure 2 is a series of plan-view and metallographic cross-sectional images of CGDS deposits. Cross-sectional images show that the aspect ratio of particles has increased to about 2, and that a highly strained region has formed near the powder-substrate interface. Further away from the interface, the powder microstructure has been preserved with very few changes. It is clear from these results that understanding the initial microstructures of the powders is crucial to determining the final microstructure after deposition and ultimately to the properties exhibited by the coating.

References:

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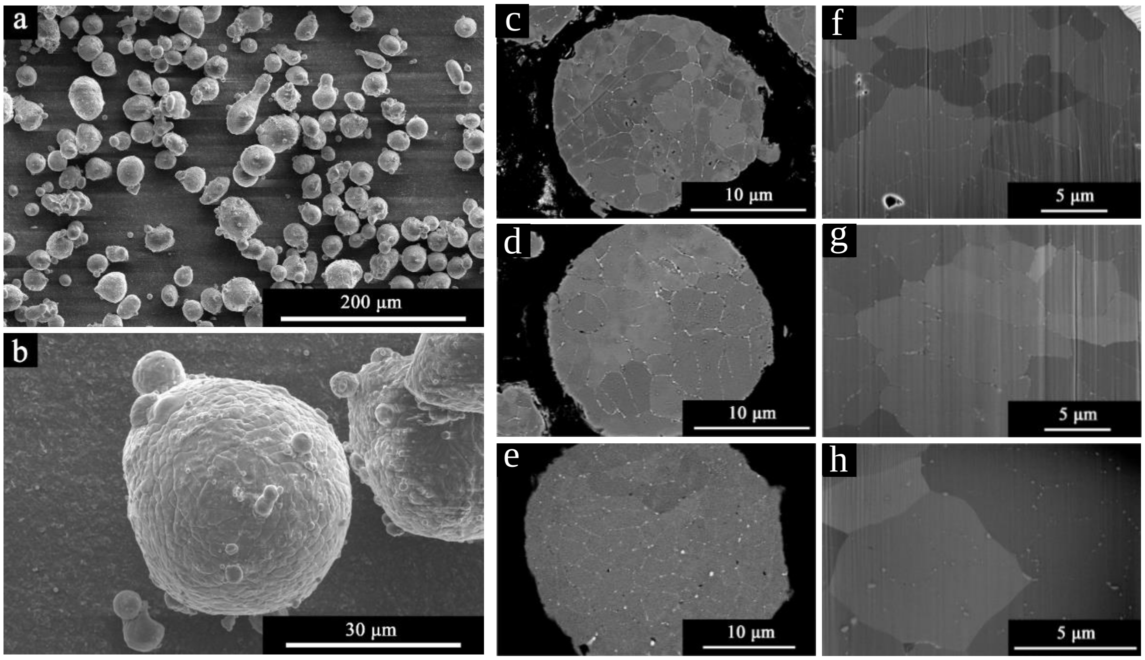

Figure 1. (a,b) SE SEM of powder surfaces, (c-e) BSE SEM of metallographic cross-sections, (f-h) SE FIB of PFIB-cut cross sections. Powders are: (c,f) as-atomized, (d,g) heat-treated, and (e,h) homogenied.

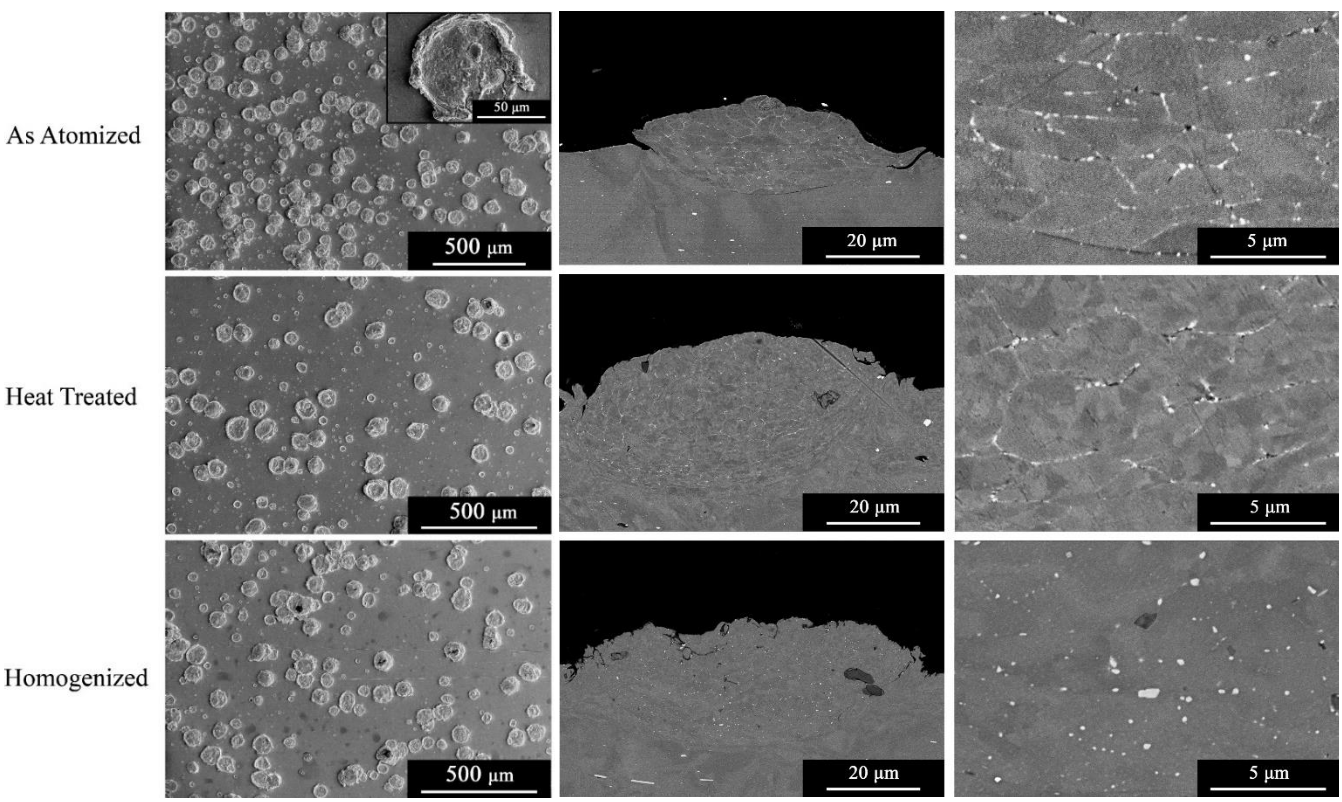

Figure 2. Plan-view and cross-sectional SEM images of Al 6061 CGDS high-pressure deposits.