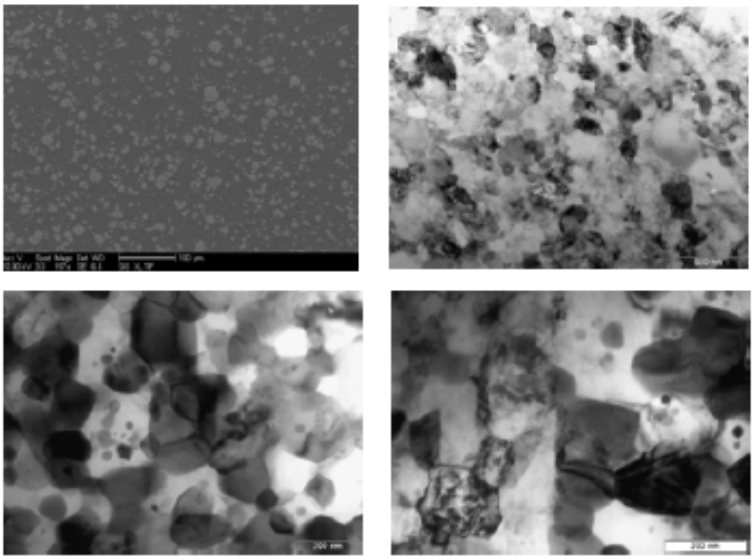
Bulk Nanostructured Aluminum Composites (DoD, ARL-ARO)

Because of their low density and excellent strength, aluminum alloys have become a workhorse material for the economy. This high strength is the result of careful metallurgical processing, which results in complex microstructures tuned to optimize the strength and toughness of the alloy. Unfortunately, because of the low melting point of aluminum, application at moderate temperatures largely reverses these metallurgical treatments. At 200ºC a nanostructured form of 5083 Al, a standard alloy used for military ground vehicles, is severely softened and its flow stress becomes comparable to conventional coarse-grained 5083 Al. Professor Lavernia's group has been working on a low-cost alternative processing technique using plasma-spray techniques in air-doped inert gasses to produce alloy 5083 Al powders. These powders include oxygen contamination in the form of Al_2O_3 clusters as small as 30Å. These particles are thermodynamically stable, so that they do net degrade or react with the alloy at lower temperatures. Their small size strengthens the alloy, and helps prevent grain-growth and other microstructure evolution at moderate temperatures. In addition, they are adding a small fraction of an Al-based metallic glass, which devitrifies during processing to form hard, ultra-fine-grained metallic particles in the alloy. These particles are metallurgically compatible with the 5083 Al. Because of this, they do not debond during loading, which would weaken the material. Since these particles do not deform, they tend to strengthen the material. In their experiments, Professor Lavernia's group has shown that the strength of the material increased by 30% at 200ºC. This could make the material a suitable replacement for steel in vehicle applications near the engine and exhaust system, which are too hot for conventional high-strength alloys.



Zhang, Z., B. Q. Han Y. Zhou, E. J. Lavernia, "Elevated temperature mechanical behavior of bulk nanostructured Al 5083–$Al_{85}Ni_{10}La_5$ composite," *Materials Science and Engineering A*, Vol. 493, 2008, 221-225.