High Performance Lightweight Materials Made by Shear Assisted Processing and Extrusion (ShAPE)

Scott Whalen[1]

[1] *Pacific Northwest National Laboratory, 3230 Innovation Blvd., Richland, WA, 99354*
(509) 372-6084; Scott.Whalen@pnnl.gov

Abstract. Shear Assisted Processing and Extrusion (ShAPE) is a new fabrication method, developed by PNNL, for extruding lightweight metals with advanced properties. ShAPE is a solid-phase technique used to extrude wire, rod, or hollow cross sections directly from powder, flake, chips or solid billets. Unlike conventional extrusion, which is an entirely linear process, ShAPE adds rotational motion to impart severe deformation into the material. The unique shearing conditions inherent to ShAPE create advanced microstructures that are impossible to achieve with conventional extrusion; even enabling processing of materials that are too brittle to extrude conventionally. Unique aspects of ShAPE are the ability to refine microstructure into the ultra-fine range, control crystallographic alignment, create nanostructured features, promote solute segregation to grain boundaries, and uniformly distribute second-phase particles within the metal matrix. By exploiting one, or a combination of these phenomena, advancements in bulk material properties are possible. An overview of the ShAPE process will be presented with examples drawn from current research in lightweight magnesium and aluminum alloys. Particular attention will be given to the microstructures achieved with ShAPE and their effect on bulk mechanical properties. Unlike severe plastic deformation techniques, ShAPE is scalable beyond an academic curiosity which has led to collaborations with numerous industry partners. PNNL's purpose built, one-of-kind in the world, ShAPE machine will be described which is capable of 100 Ton ram force while simultaneously rotating with 2,100 ft-lb of torque. This machine has been used to fabricate lightweight metals, ODS steels, semi-conducting thermoelectrics, and magnets with advanced microstructures.

Keywords: Magnesium, Aluminum, Extrusion, Lightweight Metals.