

The Importance of Powder Characterization in Metal Additive Manufacturing

*Brendan Lewis, Additive Manufacturing Technician
EWI*

Introduction

Metal additive manufacturing (AM) technologies are now capable of creating complex components from a wide range of alloys, enabling never-before-seen designs in the medical, automotive, and aerospace industries. With so many AM technologies readily available, manufacturers are now focusing on material development and processing to ensure consistent results and reliable mechanical properties in their components.

The Importance of Powder Characterization

Metal AM processes such as laser powder bed fusion (L-PBF), electron beam powder bed fusion (EB-PBF), laser directed energy deposition (L-DED), and binder jetting each utilize powders of various sizes and characteristics. These powders must be accurately characterized to repeatedly produce high-quality components with predictable properties.

Qualification of AM components is a critical issue. Many powder manufacturers who currently support conventional manufacturing processes are adapting their businesses to meet the needs of the growing AM market. While this significant increase in the number of powder suppliers has provided manufacturers with more consumable options than ever before, inconsistent powder properties pose a significant problem as the quality of additively manufactured components may be detrimentally affected.

In addition to variations in the properties of powders made by different suppliers, variations can also occur between batches of powder from the same supplier. Such variations can be attributed to the

methods of production, storage, and shipment. Common methods of powder production include plasma atomization, gas atomization, and the plasma rotation electrode process (PREP). Within each process are multiple variables that contribute to the resultant yield properties. Complete powder characterization is the best way to ensure consistent build quality by finding the right powder source.

The Effect of Powder Characteristics on Process Parameters

In addition to affecting the quality and mechanical properties of AM components, powder characteristics can also influence process parameters. For example, the oxygen pick-up commonly seen in titanium powders affects the recyclability and melting temperature, with the latter requiring adjustment of heat input to achieve a fully dense part.

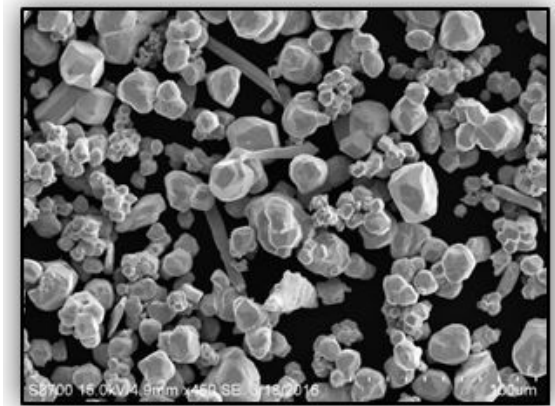


Figure 1: SEM image of tungsten powder

Powder Characterization at EWI

EWI's full powder characterization profile includes analysis of particle density, flow, morphology, size, size distribution, thermal properties, and chemical composition. EWI employs the following measurement and testing technologies to quantify these characteristics:

- **Particle size analyzer:** Reports on size distribution of particle sizes ranging from $.017\mu\text{m}$ to $2000\mu\text{m}$.
- **Hall flow meter:** Measures flowability and apparent density.
- **Scanning Electron Microscope (SEM):** Equipped with a large variable-pressure chamber to image and analyze conductive as well as non-conductive materials. Energy-dispersive x-ray (EDX) spectroscopy and electron backscatter diffraction (EBSD) allow elemental and quantitative microstructural analysis (Figure 1).
- **LECO ONH836:** Utilizes inert gas fusion technology to detect oxygen, nitrogen and hydrogen content.
- **Differential scanning calorimeter (DSC) and thermal gravimetric analyzer (TGA):** Analyze the effect of heat on powder properties.



Figure 2: TekSphero-15 powder spherodization system

Powder Spherodization

Flowability is highly governed by particle morphology, and is another important characteristic of AM powders. Spherical powders ensure optimum packing density, positively impacting the integrity and surface finish of as-built parts. Assessment in our SEM reveals whether a powder is suitable for a given AM process, or whether it requires further processing.

EWI has the capability to process non-spherical powders, making them AM-friendly. The TekSphero-15 (Figure 2) spherodizes powder using

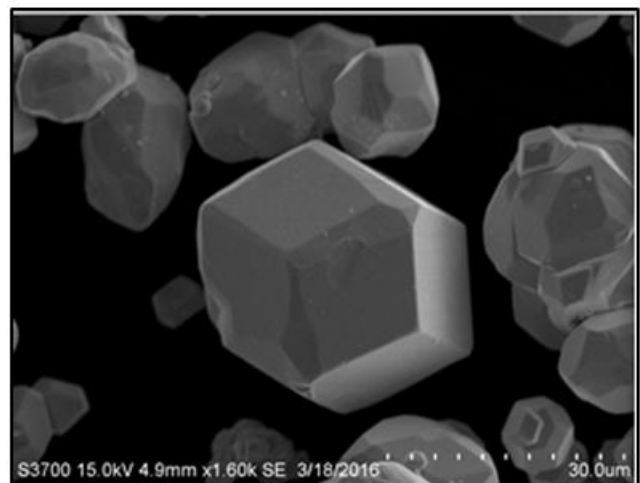


Figure 3: Tungsten powder before spherodization

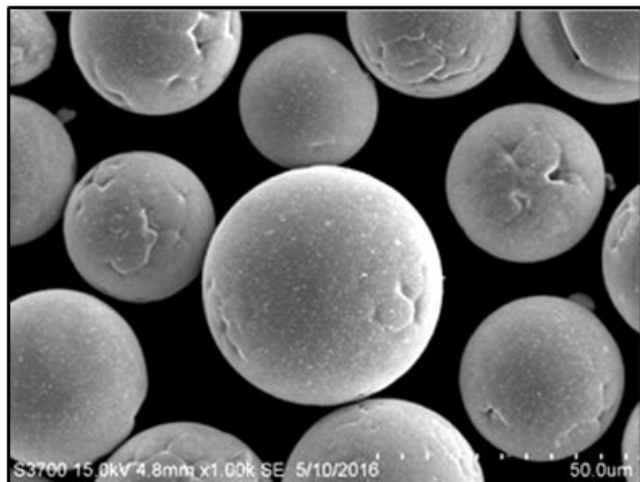


Figure 4: Tungsten powder after spherodization

induction plasma to improve powder flowability, increase density, and reduce impurity. Figures 3 and 4 show pre- and post-process results from a sample of tungsten powder. The data in Table 1 show considerable improvement for both apparent density and flow.

Table 1: Improvements to apparent density and flow

Characteristic	<i>Before</i>	<i>After</i>
Apparent Density (g/cm³)	8.2	9.0
Flow (s/50g)	7.9	6

Brendan Lewis is a member of EWI's New York-based additive manufacturing team at Buffalo Manufacturing Works. His responsibilities include supporting our high-performance AM laboratory and equipment including Arcam A2X, RPM 557, ExOne Innovent, and Sciaky EBAM-110 commercial additive manufacturing systems. In addition, he is responsible for operating and maintaining the powder characterization lab and Tekna powder spheroidization equipment.