# The curious case of the Christmas carbide particles

As the AM industry matures, and users become comfortable with the established technologies and materials, it is natural that more exotic fields will be explored. One such field is that of metal carbides, ceramics and so called cermets. With near unparalleled hardness and strength properties, but few viable forming technologies available, processing of these materials with AM represents an exciting avenue of exploration. However, AM processing is not the only hurdle, first the material needs to be available in an appropriate form, specifically spherical powder.

High temperature melting materials are typically broken down from bulk form by means of pulverisation or milling – this is made easier by chemical processes such as hydride-dehydride (HDH). The resultant material is in a granular form, and not suitable for AM processing in this state.

Fortunately, plasma spheroidisation technology - such as that held by LPW - can be used to process granular material into spherical powder which is more suitable for AM processes.

In recent months LPW has been trialling carbides and cermets on our spheroidiser. As part of these trials, samples are taken to assess the morphology and size of the product, by SEM imaging and other methods. For the most part, we are just looking at grey spheres of different sizes, but occasionally the complexities of metallurgy result in particles which are somewhat more intriguing. Here are a few examples of what we have found.

The initial spheroidisation run looked at material that had not been extensively screened prior to the trial. The particles, shown in figure 1, were found in this early WC trial, prior to any material optimisation. The homogeneous light grey particles are those containing the specified 4 wt% of carbon. However, the three particles running through the centre of the image were found to have different ratios of C to W, leading to the clear variations in particle microstructure compared to the general population. From left to right, carbon content was measured to be 21 wt% C, 7 wt% C and 9 wt% C.

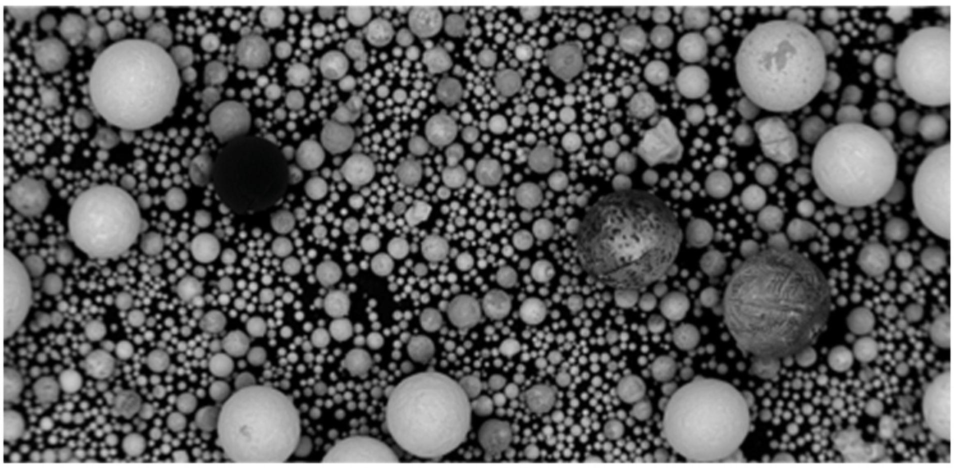

**Figure 1 - Early trial of spheroidised WC showing particles with differing elemental composition**

Given that carbon has a significantly lower atomic weight than tungsten, 21 wt% converts to an atomic percent of 80 at%, therefore carbon is actually the primary element in this particle. As a result, it is homogenous in appearance, but is considerably darker due to it being significantly less dense than the general population.

The other two particles display inhomogeneous microstructures, due to solute redistribution during solidification – either in carbon-tungsten or tungsten-carbon systems. As the molten material solidifies, the small carbon particles diffuse ahead of the solidification front creating difference concentration of solution. As the crystals grow, the higher solution concentration liquid is pushed to the boundaries. The different ratios of W to C result in different solidification kinematics, and hence we end up with a range of fascinating structures, figure 2.

Such microstructural phenomenon is not limited to the WC system. In figure 3, we see a different type of surface feature when processing Fe-WC cermet. This time we observed geometric precipitations on the surface of the particles, which after chemical analysis were revealed as a W rich secondary phase. Given the time of year of these observations, we could not help but draw comparisons with the most recognisable of crystal structures – and certainly these are the most festive of powder particles we have ever come across!

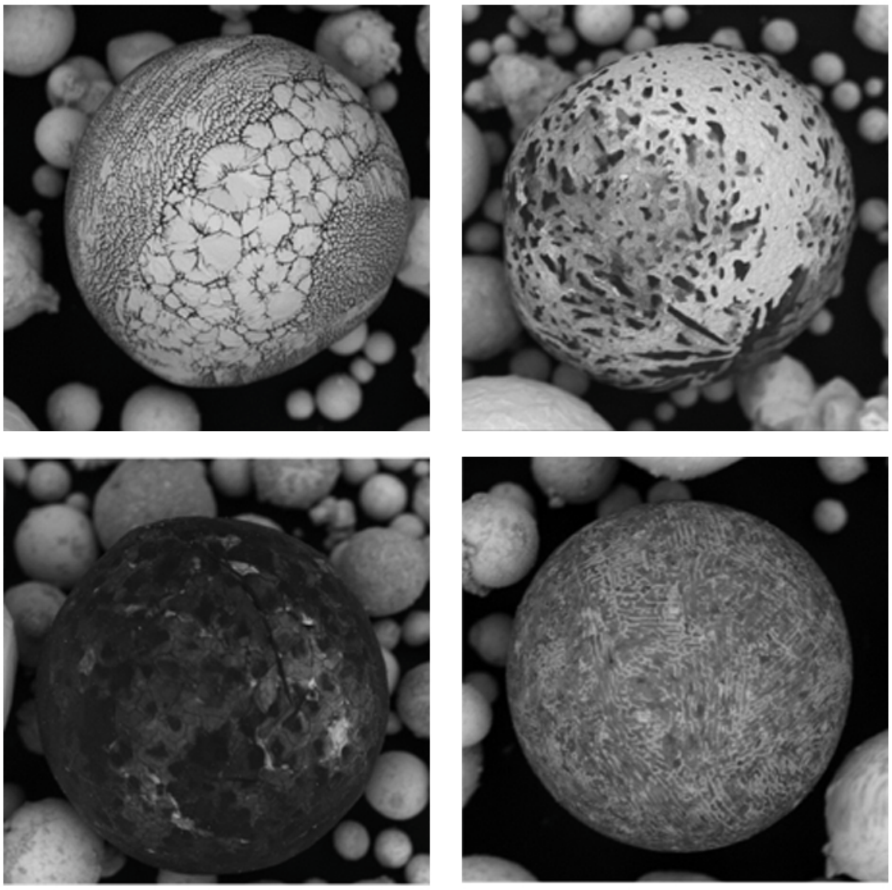

**Figure 2 - WC ratios reveal fascinating structures in metal powder particles**

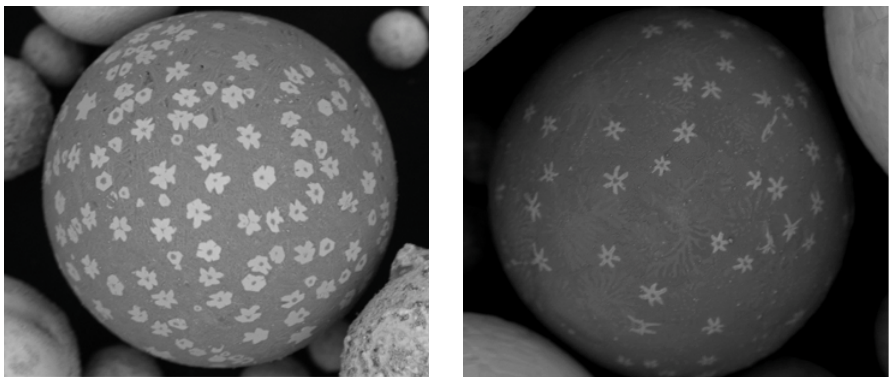

**Figure 3 - Bright coloured tungsten rich features in Fe-WC cermet powder material**