Phase Identification and Distribution Analysis by Backscattered Electrons Imaging

The composition of metal alloys has a critical influence on their mechanical and chemical properties. In order to determine the effects of alloying elements and their distribution throughout an alloy, we can utilize backscatter electrons (BE) in scanning electron microscopy (SEM).

SEM is one of the most versatile methods available to analyze the microstructure and fracture surface of a material. Figure 1 shows the interaction of electrons from an SEM electron beam with a sample. The electrons from the beam collide with the sample and produce many different particles as a result. Secondary electrons (SE) and backscattered electrons (BE) are two of the main electron emissions used in SEM imaging. SE originate from within a few nanometers of the sample's surface and are highly sensitive to surface features such as hills, valleys, edges, etc; which make SE useful for mapping surface topography. BE are strongly dependent upon the atomic number of the elements present within the sample and are often used to image composition contrast. Generally, elements with higher atomic numbers are brighter in BE images than elements with lower atomic numbers.

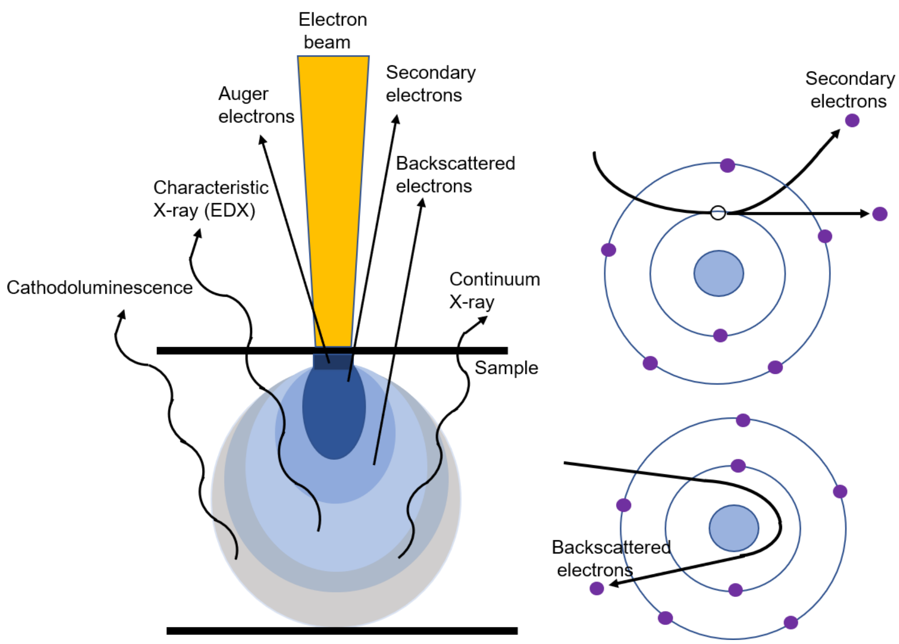

Figure 1. The interaction of electrons from the beam with the sample.

Figure 2 shows microstructural images of a Zn-Al casting. The top two images are of a polished sample and analyzed using both SE and BE. Both images showed at least two phases present, but the BE image had a higher contrast between the phases. The bright phase is composed of Zn, and the gray porous looking phase is composed of Al. The black areas on the polished surface are voids in the casting. The bottom two images in Figure 2 were taken of a fractured surface and also analyzed using SE and BE, respectively. The SE image showed great morphological detail but low contrast which made it difficult to distinguish different phases. The BE image had low morphological detail but higher contrast which made it easier to distinguish between the phases present.

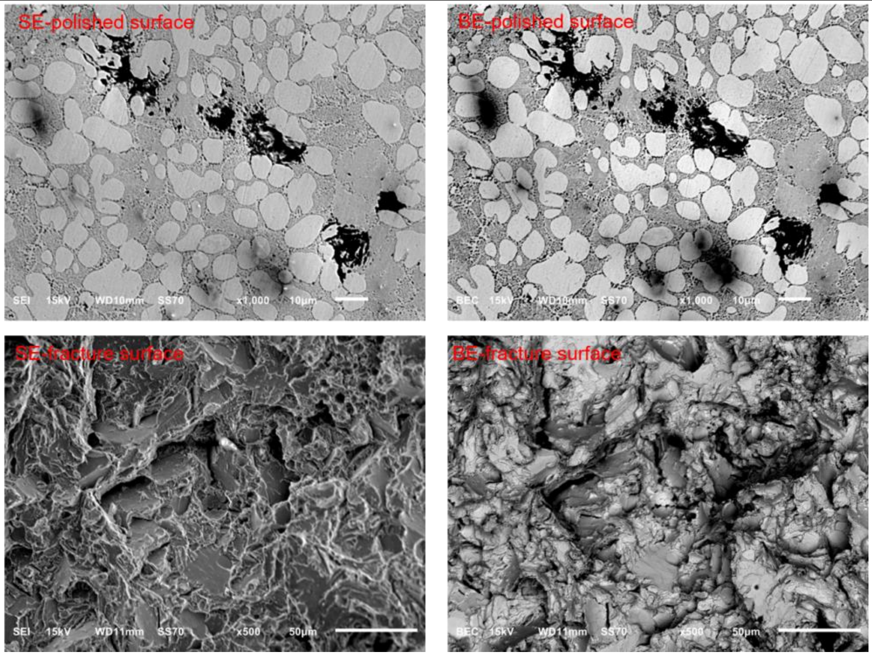

Figure 2. SE and BE images of polished and fracture surfaces of a Zn-Al casting.

In a separate project, we studied the tensile fracture surface of a 316L stainless steel sample. Figure 3 shows the SE and BE images of the 316L sample. The SE image shows a typical dimple fracture surface with some particles in the dimples. The SE image did not show a lot of contrast between the different phases, but the BE image clearly shows the contrast difference between the particles and other areas. EDS analysis found that these particles are mainly SiO_2 inclusion. Hard inclusions like these are often nucleation sites for voids during ductile failure.

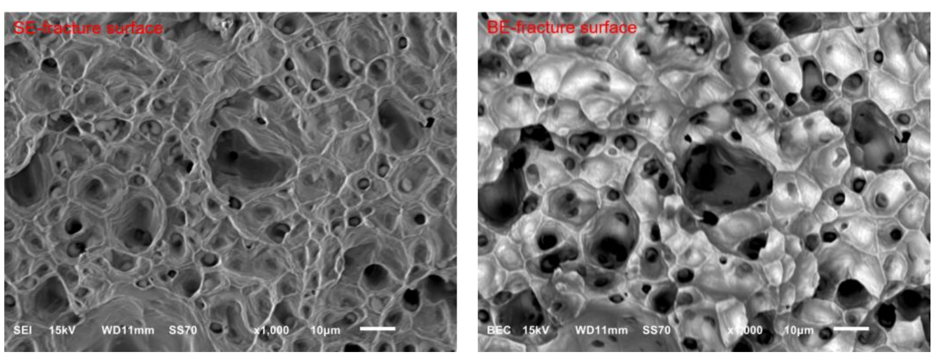

Figure 3**.** SE and BE images of 316L stainless steel tensile fracture surface.

In SEM, BE imaging is an effective method to identify distributions of different phases. This is particularly critical for studying the effects of alloying elements in metals and fracture surface analysis.