Phase Identification and Distribution Analysis through EDS Mapping

Energy Dispersive X-ray Spectrometry or EDS Analysis has become an essential tool for metallurgical analysis. EDS has been used to detect, identify and quantify elements by their characteristic X-rays emitted during electron bombardment of a specimen surface for many decades. Recent adoption of the silicon drift detector has significantly increased count rate and throughput of EDS system so that EDS elemental mapping can be carried out in a time-efficient way. An EDS hypermap that overlays surface chemical compositions and their distributions onto a secondary or backscattered electron image significantly enhances metallographic study. From this perspective, EDS analysis is especially powerful and useful for analysing the chemistry of non-metallic inclusions, to show distributions of low content alloy elements, and to meaningfully identify grains and phase structures.

Ebatco NAT Lab has recently acquired a brand-new, state-of-the-art, low vacuum JEOL JSM-6610LV scanning electron microscope (SEM) with a Bruker QUANTAX 200 EDS system. The EDS system is equipped with a Bruker XFlash® 6 | 30 silicon drift detector. With a 30 mm^2 active detection area, over 1500 kcps input count rate and over 600 kcps output count rate, high precision slider, improved heat sink and maximum solid angle, the EDS system is optimal for microscale elemental analysis, and spectral imaging with precision, accuracy and efficiency.

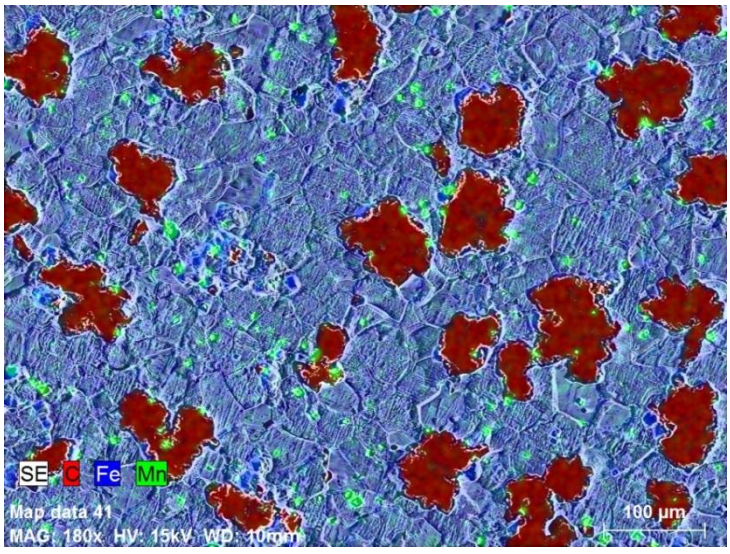

Figure 1. EDS Hypermap of Malleable Cast Iron.

Figure 1 is an EDS elemental hypermap overlaid with an SEM image of a malleable cast iron surface. The distributions of three elements: C, Fe, and Mn are shown in red, blue, and green,

respectively. The blue majority region corresponds to the ferrite matrix. Red regions are the roughly spherical aggregates of graphite that were formed after casting by the decomposition of carbides during annealing heat treatment. The scattered green dots indicate regions with high concentrations of manganese which is usually added to neutralize sulfur during casting. The remaining manganese increases the hardness of the cast iron by forming manganese carbides. Due to their small size, it would have been hard to identify the manganese carbide inclusions through optical metallography without EDS.

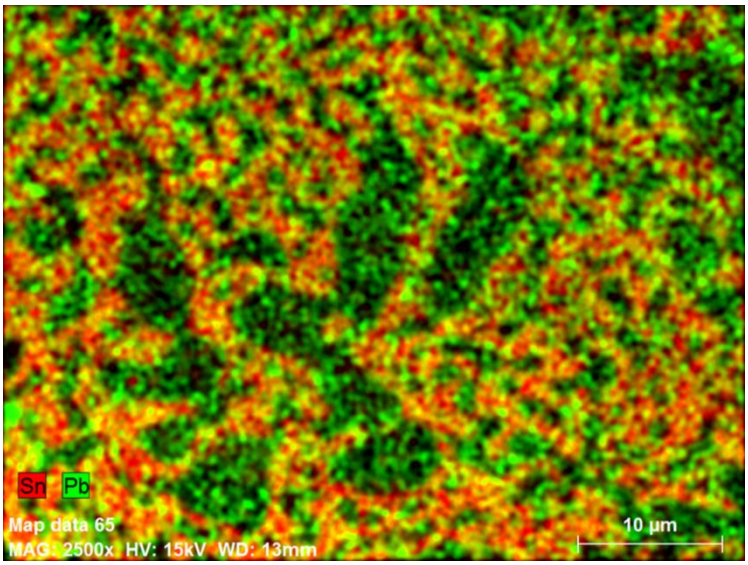

Figure 2. EDS compositional map of Pb-Sn Solder.

Figure 2 is the EDS elemental compositional map of a Pb-Sn solder material. The red and green colored regions represent tin and lead, respectively. The EDS map shows that the primary Pb-rich α phase is in the center and the lamellar Sn-rich eutectic phase makes up the surrounding area of the image. The Pb-Sn alloy has a eutectic phase transformation at 183°C with a composition of 62 wt% Sn. This temperature is considerably lower than the solidification temperatures: 232.0°C for pure Sn and 327.5°C for pure Pb. When the alloy liquid cools from melt, it forms the primary solid phase above the eutectic temperature. The composition of the primary solid phase depends on the alloy content. If the Sn content of the alloy liquid is less than 62 wt%, the Pb-rich α phase forms first, otherwise the Sn-rich β phase forms first. As solidification proceeds to the eutectic temperature, the eutectic phases α + β start to form in the surroundings of the solidified primary phase. The eutectic phases are usually in lamellar structures with α and β phase in alternate layers. In this study, the EDS element map clearly shows the primary phase is lead-rich α phase, which indicates that the Sn content of this alloy is less than 62 wt%.