Investigation of Mg-Li-Ca alloys using a Wavelength Dispersive Soft X-ray Emission Spectrometer and EPMA

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A new group of ultra-lightweight magnesium-lithium-calcium alloys have recently been developed. These innovative alloys have some superior characteristic including high specific strength. These unique, and long sought after features, will soon lead to the use of these alloys in personal computers, aircraft, trains, automobiles, and many other manufactured products. However, the microanalysis of these alloys is significantly more challenging due to the presence of lithium. The presence of lithium limits the available analytical techniques to either that of using ultra, low-energy X-rays, or a surface analysis technique. A new method for analyzing the ultra low-energy X-rays was applied to these challenging alloys.

We chose to analyze the lithium and magnesium using the Li-K and Mg-L X-ray emission using a newly developed wavelength dispersive, soft X-ray emission spectrometer (WD-SXES) attached to an electron probe microanalyzer (JEOL EPMA JXA-8230)[1-3]. The sample investigated is in the ternary Mg-Li-Ca system. Sample preparation involved using an ion cross-section polisher (CP) to both polish and flatten the oxidized surface. The WD-SXES was tuned the lower limit to allow for the detection of the Mg-L emission at between 50 to 45eV. Spectrum element mapping was acquired using the lower energy Mg L, Li-K and Ca-Lℓ emissions. These elemental maps and the backscattered electron image are shown in Figure 1, and spectra from the precipitates and matrix are compared in Figure 2. The element mapping shows that the Mg and Li are in a higher abundance in the darker phase (BEI) than in the lighter phase. The spectra data provide additional insights into their structure. The sharp leading edge of the Mg-L emission line at 50 eV corresponds to the Fermi-edge, and its unique lower energy profile corresponds to the electron density of state due to the brillouin zone [4]. Therefore different peak shapes must correspond to structural states of the two phases. The Li-K emission is also clearly detected and can be seen to have a higher concentration in the precipitate than in the matrix.

Using the WD-SXES to investigate these alloys clearly shows that this method of spectrum map is useful in distinguishing both the chemical bonding states and the distribution of magnesium and lithium between the phases.
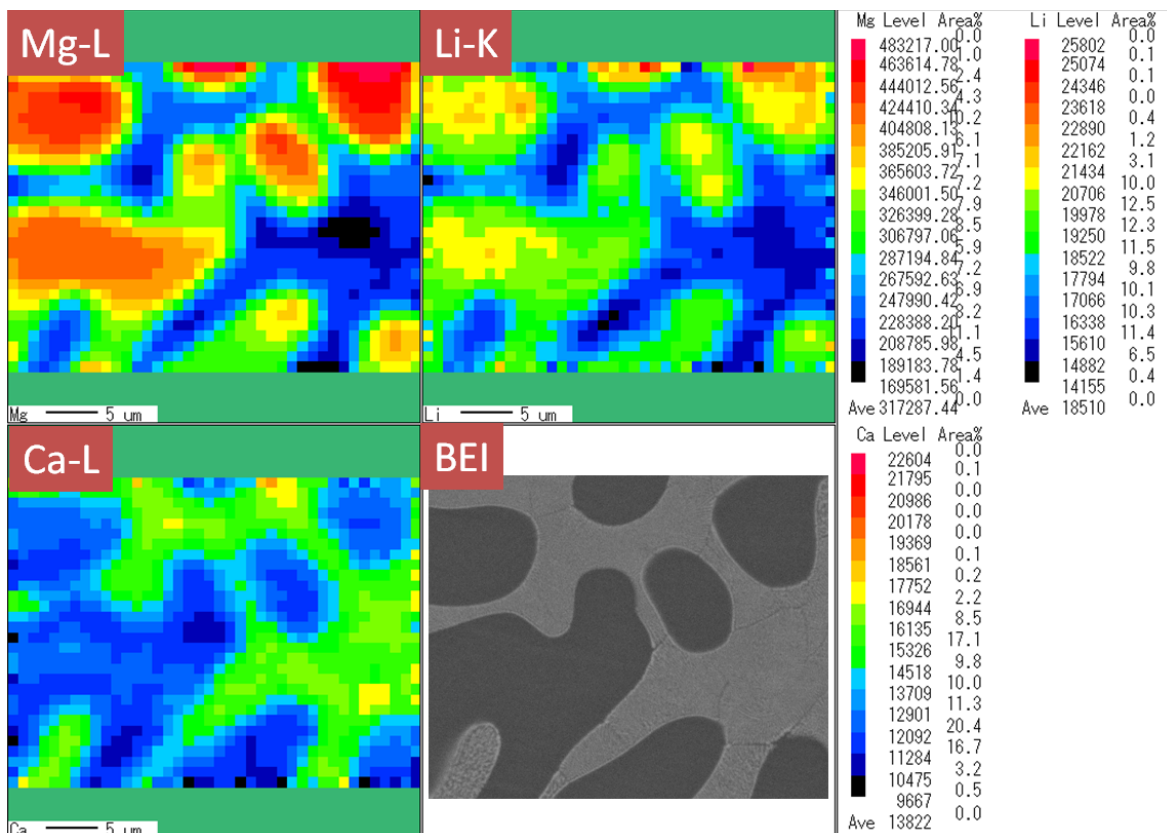
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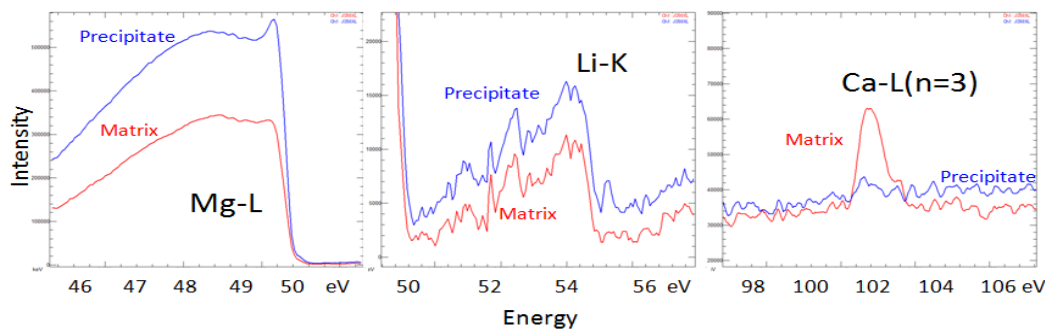 [1] M. Terauchi, et al., J. Electron Microscopy, 61, 1 (2012).
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Figure 1. Elemental distribution of Mg, Li, and Ca and backscattered electron image using WD-SXES-EPMA JXA-8230.

Figure 2. Comparison of Mg-L, Li-K and Ca-Lℓ(n=3) spectra from the two phases in the Mg-Li-Ca alloy. Red solid line - Matrix; blue solid line - Precipitate.