B8: Formation of Ta-rich magnetite phases in WEEE recycling slags through modification and controlled cooling

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Overview

Nowadays, waste electrical and electronic equipment (WEEE) is recycled using the route of secondary copper refining (Hagelüken 2006, Latacz 2020). This route involves several pyro- and hydrometallurgical steps where WEEE is sold as a low-grade Cu scrap. During the pyrometallurgical processing, most valuable elements with high affinity by oxygen such as REE (rare earth elements), Mo, or Ta, ended up diluted in the fayalitic slags used by the copper industry and thus lost for recycling (Ueberschaar 2017, Reuter 2019, Habashi 1998). A metal wheel (Figure 1), created over the years, shows the interdependencies between several elements and the probability of whether an element remains dissolved in the metal phase as an accompanying element or is segregated to the (oxidised) slag phase.

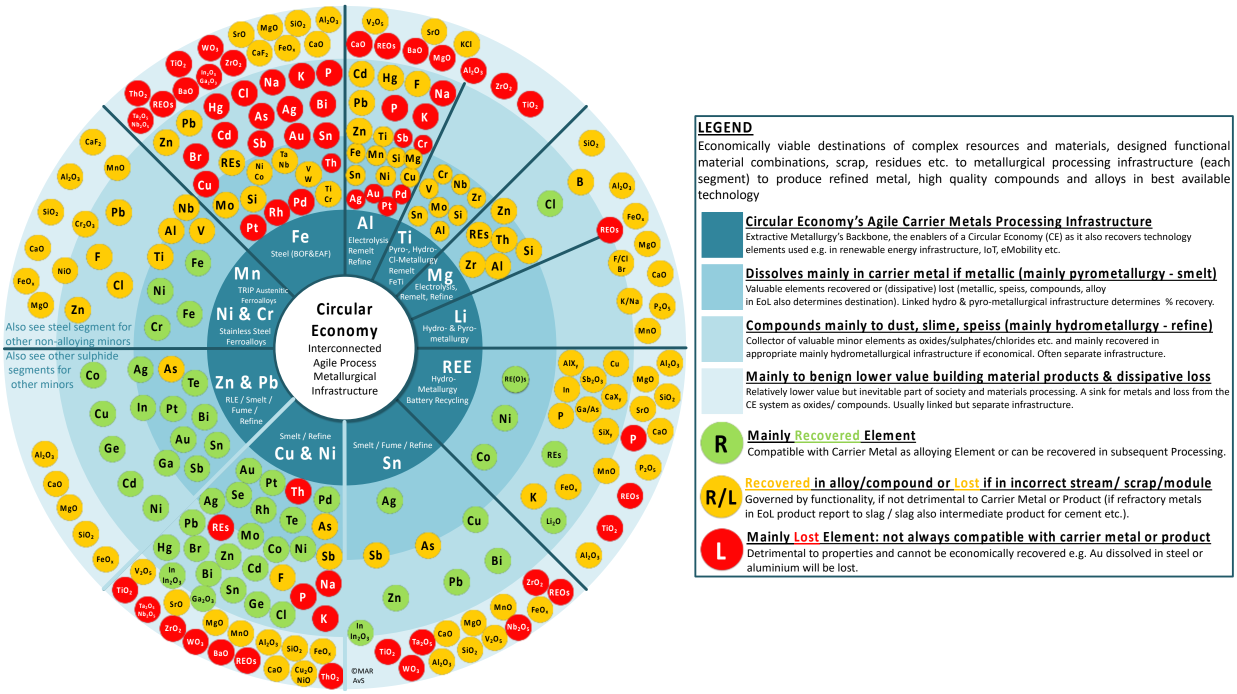

Figure 1: Metal wheel for pyrometallurgical processes indicating the interaction (i.e. solubility, affinity) of metals. The colour code also shows the inevitable material discharge (loss) from the circle (Reuter 2019).

The SPP 2315 addresses the slag phase of metallurgical recycling processes as an important source of critical technology elements. In subproject B8, artificial magnetic minerals' formation and growth mechanism are explored to concentrate and selectively capture Ta (Hagelüken 2006) from WEEE. This phenomenon is strongly affected by the process conditions such as liquidus temperature, cooling rates, oxygen partial pressure in the melt, as well as the oxidation state of different ions in the slag called fayalite—an iron orthosilicate with the olivine crystal structure (Fe_2SiO_4)—capturing Ta during this process. Fayalite is usually associated with magnetite since it is constrained under oxidizing conditions by the breakdown into quartz plus magnetite at the quartz-fayalite-magnetite (QFM) phase boundary (Mackwell 1992). Magnetite content in fayalitic slag will depend on the diffusion of oxygen and solid mixtures precipitation, which is why fayalitic slags are partially magnetics at low temperatures (Mackwell 1992, Kozlenko 2019, Du 2020).

Figure 2 depicts a graphical representation of the intended methods. During crystallization and formation of the Fe-inversed spinel structure, Ta should be sequestered into the amorphous phases, ultimately forming a solid Ta-containing solution. This process results in a solid formation of an artificial mineral, segregated from the liquid by gravity and the solid-liquid stresses. The segregated magnetite will agglomerate to form clusters that will undergo a settling process. The process takes place in a static crystallizer, which allows controlling the inorganic crystal's growth direction and improves the precipitated magnetite's segregation from the fayalitic slag.

Through controlling crystallization and engineering mineral formation, we are seeking to selectively concentrate Ta into a magnetic mineral matrix that could later be recovered by magnetic separation, transforming this fraction into raw material for extracting Ta.

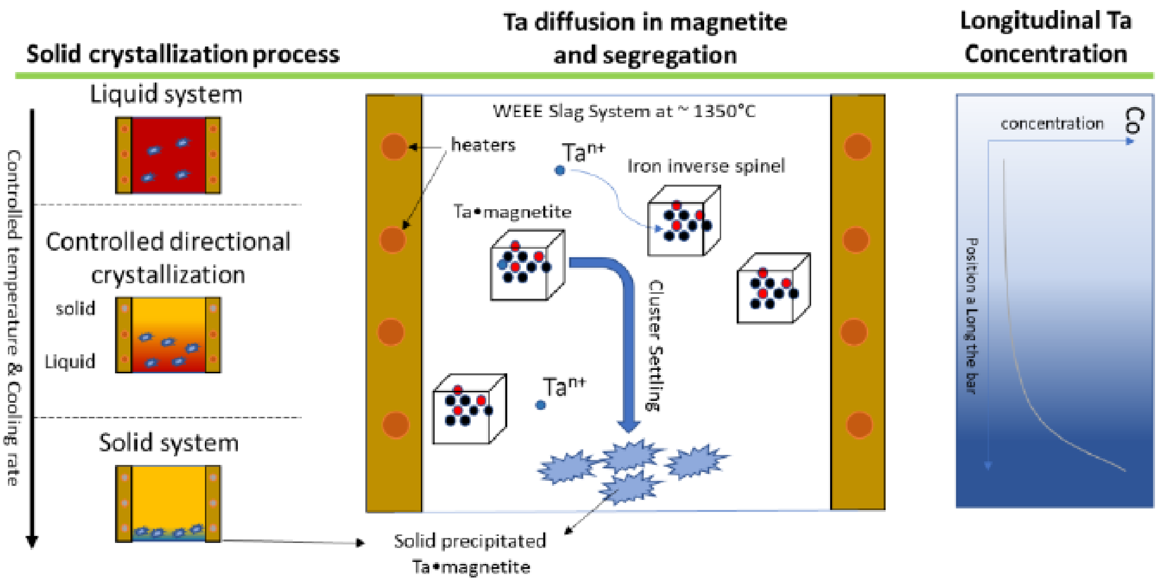

Figure 2: Schematic representation of Ta concentration in magnetite phase.

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