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Thermal plasma extractive metallurgy: a proof of concept

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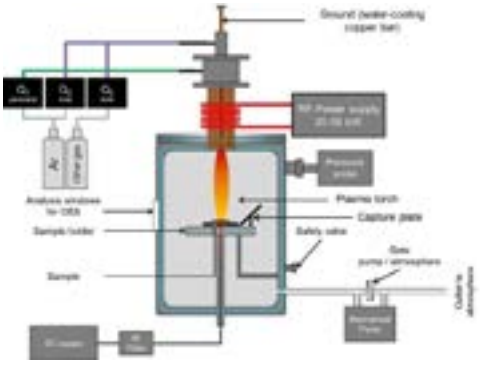
Statement of the Problem: Recycling processes are now widely recognized as one of the solutions against the primary mineral resources supply risk. The most developed countries are aware of this issue and aim to find innovative processes to recycle strategical metallic elements. The existing processes are pyro and/or hydrometallurgical processes; however, they may face significant drawbacks. Within the framework of alternative new recycling processes, we use the thermal plasma media to perform extractive metallurgy. Indeed, the so-called 4th state of matter combines the properties of hydro and pyro-metallurgical processes in addition to its properties.

Methodology & Theoretical Orientation: The selective extraction and recovery of desired metal in binary samples alloys (FeCu, CuSn) has been carried out by a 15 kW enhanced plasma process. The enhancement lies in the modification (additives) and the control of the hot plasma chemical reactivity and temperature. The liquid alloy mass transport is also studied and controlled (by a DC bias) to understand the plasma-alloy interface and optimize the extraction. The extracted elements are transported by the plasma flow and recovered by condensation on a capture plate.

Findings: The understanding and the control of the plasma-alloy interface led to the selective extraction of the desired elements with a high purity. Some plasma thermodynamic tools have been conceived to improve the selectivity and extraction rate. Multiple diagnosis tools (OES, LIBS, DRX, ICP) are employed in situ and ex situ so that an extraction mechanism can be proposed.

Conclusion & Significance: The thermal plasma is a suitable media for metallurgical processes. In this project, we used a customizable and controllable thermal plasma process to selectively extract and recover metal from binary alloy (Cu, Sn), with further objective to recycle strategic metals from more diverse and complex matrices.



Schematic illustration of the thermal plasma extractive metallurgy process

Biography

Jonathan S Cramer is a second year PhD student specialized in Electrochemistry Chemical Engineering and Material Chemistry for applications in sustainable industries. During his Master's studies, he had the opportunity to work on topics such as: the durability of reinforced concrete building in the marine environment and the corrosion behaviour of hybrid aeronautic materials. Later on, he focused on new alternative recycling processes destined to high value metallic wastes. Moreover, he worked as a Research Engineer on the set up of a molten salt electrochemical process for the recycling of super-alloys on end of life aircrafts. Now, as a PhD student, he investigates the implementation of a new thermal plasma process destined to the recycling of Waste Electrical & Electronic Equipment (WEEE).

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