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#9-188 Development of an X-ray fluorescence spectro-imaging instrument, based on Timepix3 counting chip, adapted for electronic waste sorting.

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The increasing use of electronic devices in our daily lives makes the recycling of these devices a major challenge. Indeed, the production of such equipment requires the use of many metals, including rare earth elements, whose extraction raises numerous environmental, strategic, and economic issues. In nature, these mineral deposits are sparsely concentrated, making their extraction complex, costly, and polluting. Moreover, Europe has very few rare earth deposits, which makes it highly dependent on foreign powers for its supply. Thus, better utilization of urban mining would not only reduce the environmental impact of rare earth extraction, but also make better use of resources that are currently wasted, and decrease dependence on producing countries. Despite all these challenges, the recycling of WEEE (Waste Electrical and Electronic Equipment) is still underdeveloped today. Due to the low concentration of these elements in electronic devices, current sorting methods make their recovery difficult and economically unprofitable, hence the need to develop new innovative sorting methods. The CEA IRAMIS institute is currently developing different sorting strategies. One of these strategies involves optical sorting of electronic waste using artificial intelligence. This artificial intelligence has been trained on a database of electronic components in order to associate an elemental composition with a specific component shape. Thus, the combination of this artificial intelligence with a simple visible camera theoretically allows the sorting of different components. However, similar-shaped components may differ in their chemical composition, so optical information alone is insufficient for sorting. Therefore, a sorting strategy using X-ray transmission spectrometry is considered. This method involves irradiating electronic components with an X-ray source, while a detector placed on the other side of the samples measures the energy of the transmitted radiation. By measuring the intensity of the X-rays transmitted compared to the incident intensity, they can determine the nature of the elements present in the sample, as each element has a characteristic absorption spectrum. Unlike the previous method, this one has the advantage of directly providing information on the elemental composition of the samples; however, X-ray transmission is not usually used for this purpose, as other methods are better suited. The objective of this work is to design a new strategy for sorting WEEE that complements methods presented earlier. In this work, the chosen method for elemental discrimination relies on X-ray fluorescence spectro-imaging. When irradiated by an X-ray source, samples emit X-ray fluorescence radiation, with energy levels specific to the chemical elements they contain. Thus, by measuring theses radiations, we can determine the elemental composition of the sample. Analysing an energy signature, rather than an absorption profile, gives X-ray fluorescence spectrometry greater sensitivity compared to X-ray transmission spectrometry. On the other hand, imaging of the fluorescence radiation from the samples is made possible by using a pixelated detector equipped with a collimator designed for X-ray imaging. The combination of spectrometry and imaging, known as spectro-imaging technique, would significantly enhance the sorting process by enabling the localisation and identification of samples within in a given field-of-view. The developed system in place is as follows: an X-ray generator irradiates the sorting bench; while a Timepix3 based pixelated detector, comprising 256×256 pixels with a 55 µm pitch, hybridized with a 100 µm thick silicon semiconductor, faces the conveyor belt and is equipped with a coded-aperture collimator to detect the fluorescence radiation emitted by the samples. This experimental setup has shown promising performance during several trials, which include the analysis of pure element samples as well as samples more representative of the WEEE sorting application.

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