Characterization of electronic waste by nuclear analytical and imaging techniques

László Szentmiklósi[a,], Mariann Papp[a,b], Zoltán Kis[a], Dénes Párkányi[a], Boglárka Maróti[a]*

[a] *Centre for Energy Research, Hungarian Academy of Sciences, 29-33 Konkoly-Thege Miklós street 1121 Budapest, Hungary;*

[b] *Faculty of Natural Sciences, Roland Eötvös University (ELTE), 1/A Pázmány Péter sétány 1117 Budapest, Hungary;*

** Corresponding author: szentmiklosi.laszlo@energia.mta.hu*

In modern society the life-cycle of electronic equipment is continuously shortening and consequently the amount of e-waste is growing year by year. Therefore, since 2003, a Restriction of Hazardous Substances (RoHS) [1] has been adopted by the European Council to regulate the hazardous or toxic components of commercial products. During production other substances with great economic importance (such as rare earth elements, noble metals) are also used, therefore the waste, if recycled, can be considered as a valuable resource of these elements. In the course of the present study completed at the Budapest Neutron Centre [2], we evaluated the applicability of neutron analytical and imaging methods in the characterization of legacy electronic waste.

Elemental compositions and structural details of selected historical e-waste were determined. Samples and analysis spots were selected based on our *a priori* knowledge where the presence of valuable or toxic elements was expected. During the study, in addition to the main components, indium, samarium, gadolinium, neodymium, tungsten, silver, platinum and gold were positively identified. With prompt-gamma activation imaging (PGAI), the spatial distribution of the elements within a computer memory card could be directly studied. In the slices at an IC elevated concentrations of hydrogen, silicon, nickel and iron were observed, whereas high Ti and Sm content was found in the resistors in-between the chips. The levels of B, Ca, Cl, Br and Cu were found to be rather constant along the long axis of the memory card, so most likely they are part of the base composite plastic.

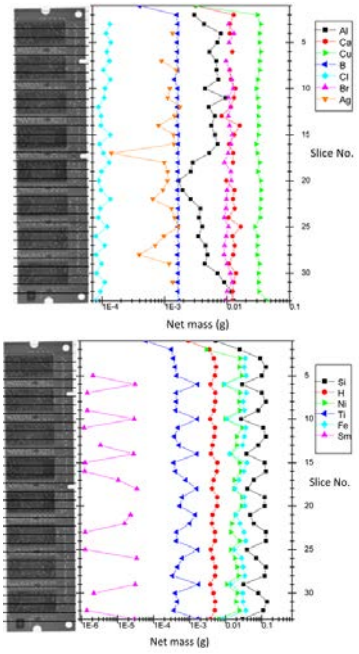

Figure 1: The element profile of a computer SDRAM module

Three samples were studied with in-beam neutron activation analysis. The in-beam NAA spectra of the activated samples often provided more reliable identification of elements that were at the margin of detectability with PGAA.

With neutron and X-ray imaging the heterogeneity of the samples could be visualized, and the spatial distribution of certain components could be defined, so imaging is a useful addition to correctly interpret the element analysis results. We found that the analyzed electronic waste samples do contain many of the critical elements initiative, such as platinum or rare earth elements.

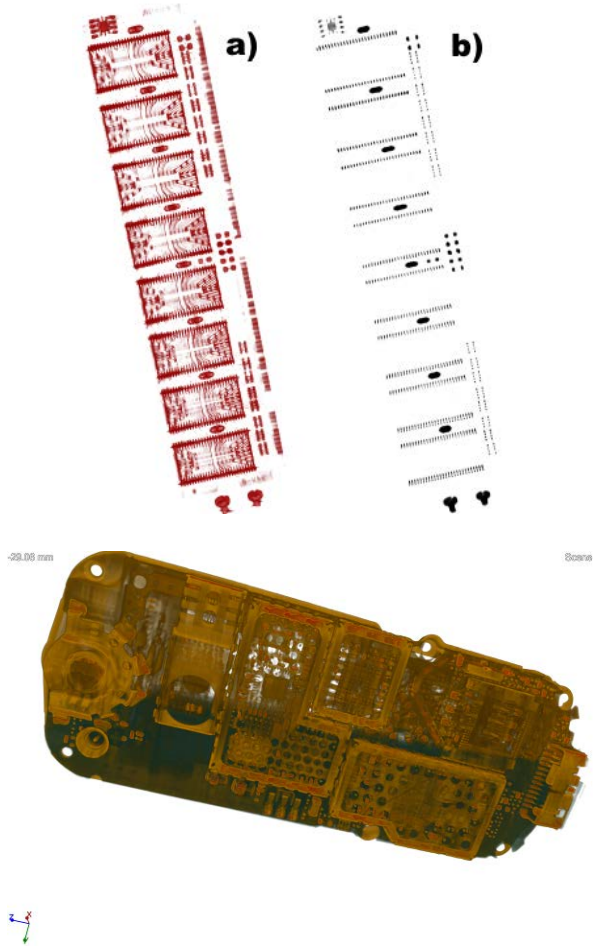

Figure 2: The visual segmentation of the parts based on multi-modality grayscale values

[1] DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0065&from=EN

[2] The homepage of the Budapest Neutron Centre: http://www.bnc.hu