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Amphi F

Challenges and New Processes in the Recycling of Printed Circuit Boards

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Conventional recovery and recycling of Printed Circuit Boards (PCBs), requires first a labor intensive process for their isolation, followed by mostly manual retrieval of high value electronic components (ECs), prior for the reminder to be crushed for further processing by hydrometallurgy and electrorefining processes. This allows for the recovery of the main elements (by weight or value), but all other elements are oxidized, mixed, diluted and therefore lost in post-processing wastes or ashes. To retrieve these elements, we are studying a change of paradigm: the disassembly of WPCBs combined with the sorting of ECs, followed by the fast development of physical and chemical treatments specific to each sorting bin [1, 2]. This enables ECs to be separated by composition and to significantly increase their chemical element‘s concentration and simplifying the waste’s composition, thus making minority metal’s recovery economically viable. In this presentation, we will rapidly present current state-of-the-art processes for PCBs. We will then identify research and business opportunities in the case of some elements such as refractory metals (Ta, Nb, W, Mo), gallium, or lanthanides as well as present our laboratory's results beyond the state of the art regarding: (i) new physical recycling treatment of wasted PCBs [1]; (ii) the fast process development using an instrumented microfluidic platform [2]; (iii) Example of new processes for the recovery of strategic metals[3]; and (iv) their upcycling into nanomaterials/catalysts [4].

[1] « Dismantling of Printed Circuit Boards Enabling Electronic Components Sorting and Their Subsequent Treatment Open Improved Elemental Sustainability Opportunities » Ange Maurice, Khang Ngoc Dinh, Nicolas Charpentier, Andrea Brambilla, Jean-Christophe P. Gabriel, Sustainability 13(18), 10357 (2021) https://doi.org/10.3390/su131810357 .

[2] (a) « Microfluidic lab-on-chip advances for liquid-liquid extraction process studies ». Ange Maurice, Johannes Theisen, Jean-Christophe P. Gabriel, Current Opinion In Colloid & Interface Science 46, 20-35 (2020). https://doi.org/10.1016/j.cocis.2020.03.001 ; (b) « First online X-ray fluorescence characterization of liquid-liquid extraction in microfluidics.» Ange A. Maurice, Johannes Theisen, Varun Rai, Fabien Olivier, Asmae El Maangar, Jean Duhamet, Thomas Zemb, Jean-Christophe P. Gabriel, Nano Select 2021, 1-12 (2021) https://doi.org/10.1002/nano.202100133; (c) « Liquid-liquid extraction: thermodynamics-kinetics driven processes explored by microfluidics.» Fabien Olivier, Ange A. Maurice, Jean-Christophe P. Gabriel, Comptes Rendus Chim. 25, 137-148 (2022). https://doi.org/10.5802/crchim.172 ; (d) « On-line Quantification of Solid-Phase Metal Extraction Efficiencies Using Instrumented Millifluidics Platform » Fabien L. Olivier, Sarah M. Chevrier, Barbara Keller, and Jean-Christophe P. Gabriel, submitted for publication (2022).

[3] « Sustainable Route for Nd Recycling from Waste Electronic Components Featured with Unique Element-Specific Sorting Enabling Simplified Hydrometallurgy. » Dong Xia, Nicolas M. Charpentier, Ange A. Maurice, Andrea Brambilla, Qingyu Yan, Jean-Christophe P. Gabriel, Chemical Engineering Journal 441, 135886 (2022). https://doi.org/10.1016/j.cej.2022.135886

[4] « Efficient Electrocatalyst Nanoparticles from Upcycled Class II Capacitors» Junhua Xu, Daobin Liu, Carmen Lee, Pierre Feydi, Marlene Chapuis, Jing Yu, Emmanuel Billy, Qingyu Yan, Jean-Christophe P. Gabriel, Nanomaterials 12(15) 2697 (2022). https://doi.org/10.3390/nano12152697

Biography

JC Gabriel is Research Director in Nanosciences at the Alternative Energy and Atomic Energy Commission, CEA. Since 2018, he co-directs the "NTU Singapore CEA Alliance for Research in Circular Economy" (SCARCE), hosted by the Nanyang Technological University where he serves as Visiting Professor and develops new processes for the recycling of e-wastes, a field he started investigating in 2013. He joined CEA in 2007 as CEA/LETI institute's "Beyond CMOS" program manager. From 2009 to 2016 he was deputy director of CEA's Nanoscience Funding Program. Overall, His career is a mixed academic – industrial one dealing with nanomaterials, including 6 years in a Berkeley's spinoff (www.nano.com), which was the first company to put an integrated nanotube based electronic device on the market (2005) and where he helped raised $34 million. Former student at the "Ecole Normale Supérieure" in Paris, he holds a Ph. D. from Paris-Saclay University, published 75+ publications and co-invented 50+ patents/applications.