



# Unlocking value in low-grade PCBAs

GOING GREEN – CARE INNOVATION

MAY 9TH, 2023

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The project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement N° 958302



# Printed Circuit Boards Assemblies (PCBAs)

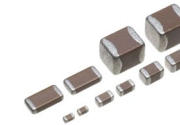


**Au, Cu, Si**



*Integrated circuit*

**Pd, Ag, Ni**



*Multilayer ceramic capacitor (MLCCs)*

**Ta, Ni**



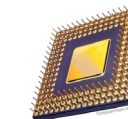
*Tantalum and niobium capacitor*

**Nd**



*Vibration motor (mobile phone and smartphone)*

**Au, Cu, Si**



*Central Processing Unit (CPU)*

**Cu**



*Printed Circuit Board (PCB)*

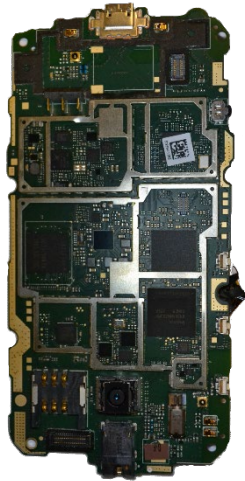
**Sn, Ag, Pb**



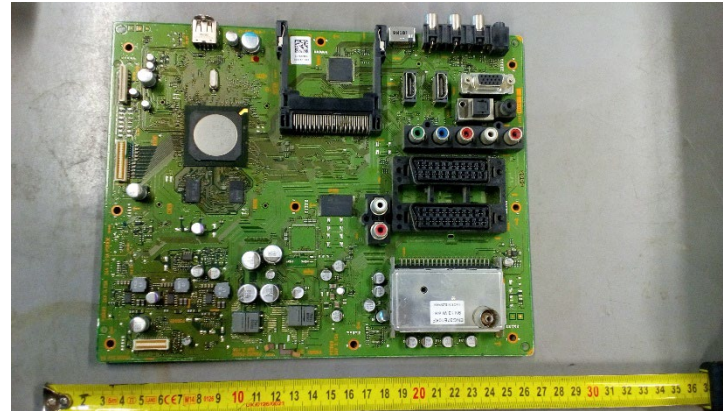
*Solders*

# Are all PCBAs equals?

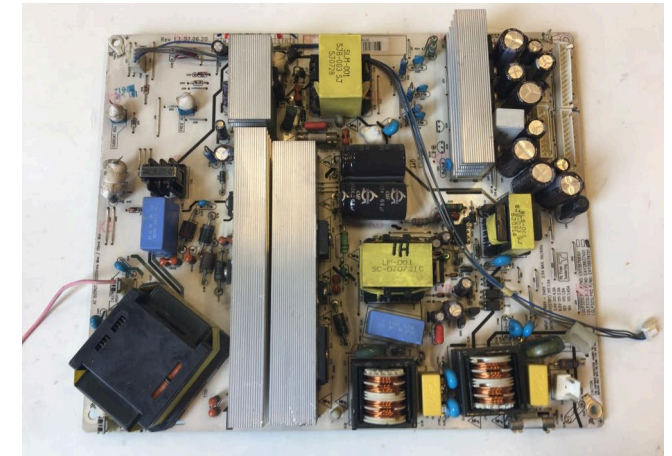
Main PCBA of a **smartphone**  
(Nokia Lumia 510)



Motherboard from a **LCD TV**

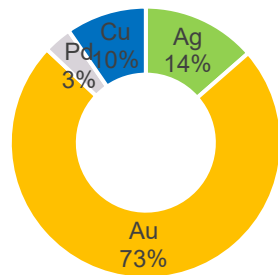


Motherboard from a **CRT TV**



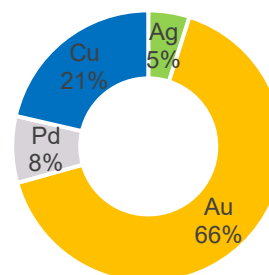
	<b>Grade</b> [g/t]
Ag	8654
Au	532
Pd	31
	<b>[%]</b>
Cu	46,0%

**Intrinsic value**  
**43,786 €/t**



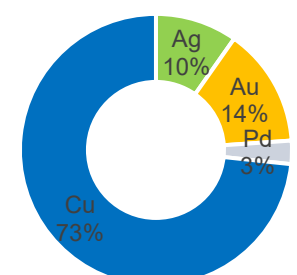
	<b>Grade</b> [g/t]
Ag	513
Au	78
Pd	12
	<b>[%]</b>
Cu	16,8%

**Intrinsic value**  
**7,032 €/t**



	<b>Grade</b> [g/t]
Ag	243
Au	4
Pd	1
	<b>[%]</b>
Cu	13,7%

**Intrinsic value**  
**1,622 €/t**

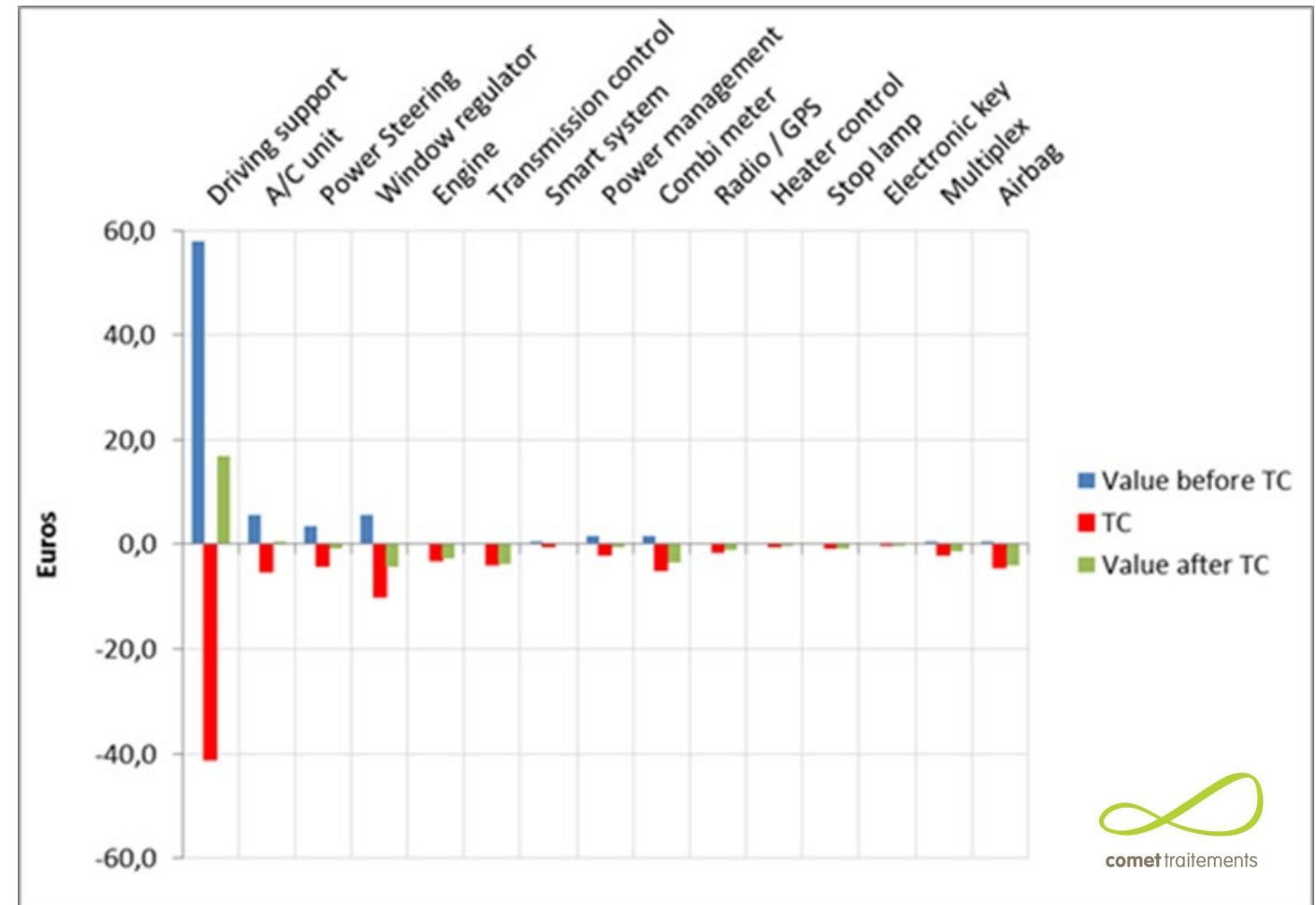


# Getting a hand at PCBAs

***Dismantling is not always economical.***

- Depends on
  - Dismantling cost
  - PMs grades
  - Current metal prices
  - ...

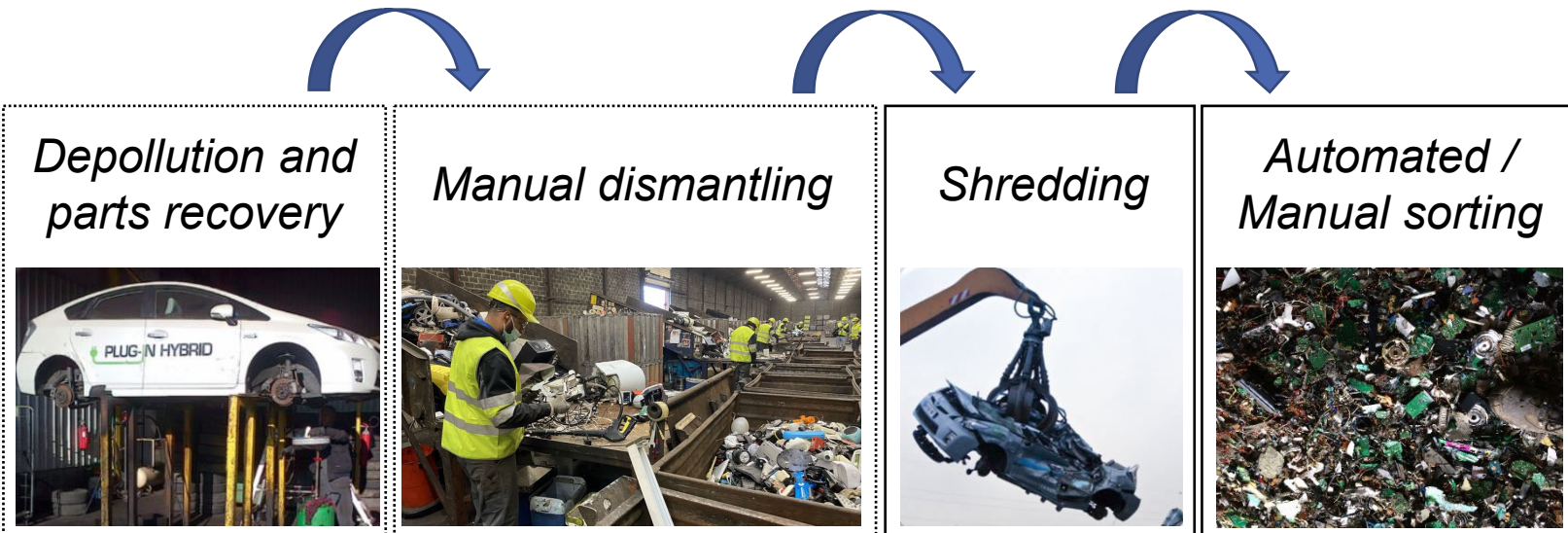
***If not, PCBs are collected after ELVs and WEEE shredding***



From 15 Electronic Control Units (ECU) of the Toyota Prius Plug-in, only 2 could be dismantled economically (*Comet Traitements*).

# Post-shredder PCBs

## Case of study (*Comet Traitements*)

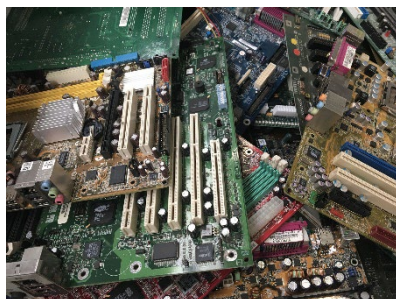


## Post-shredder PCBs



Typical post-shredder PCBs

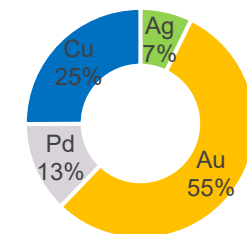
PCBAs economically dismantled



	Grade [g/t]
Ag	445
Au	42
Pd	13
	[%]
Cu	13,7%

## Intrinsic value

**4,602 € / t**



# Recycling PCBAs

Computers - Smartphone

CRT and LCD TVs

ELVs

Dismantling / Shredding / No pretreatment

*Based on economic evaluation*

High-grade PCBAs

Mid-grade PCBAs

Low-grade PCBAs

Pyrometallurgy Smelter

*Depending on metal prices,...*

Exported outside EU - Sub-economic for direct smelting

# Recycling PCBAs

Computers - Smartphone

CRT and LCD TVs

ELVs

Dismantling / Shredding / No pretreatment

Based on economic evaluation

High-grade PCBAs

Mid-grade PCBAs

Low-grade PCBAs

Pyrometallurgy Smelter

Depending on metal prices,...

NOVA process

Developed by Uliège and Comet Traitements within Reverse Metallurgy project

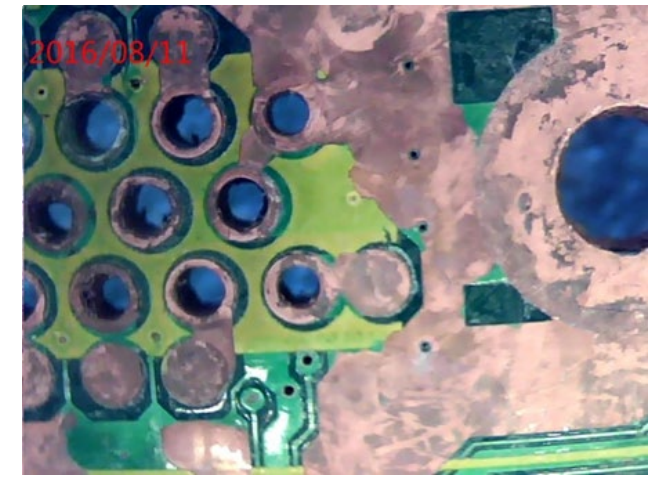
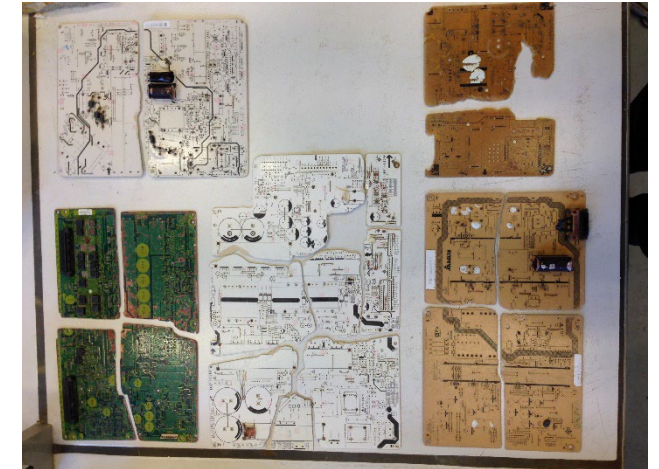
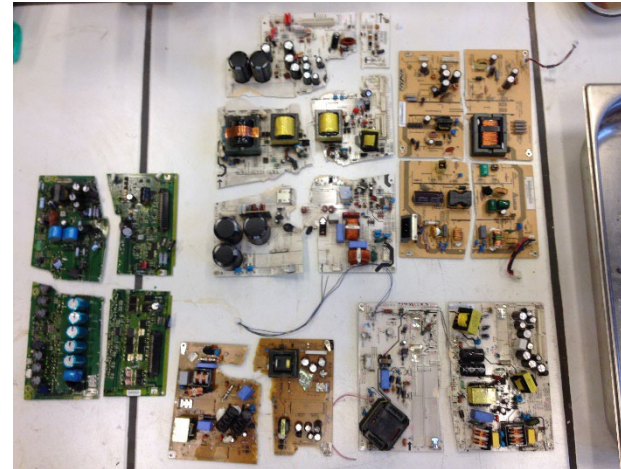


# The NOVA process

***Aims at unlocking the value of PMs, tin and copper by electrochemistry and mechanical activation***

*Before*

*After*





# The NOVA process applied to PCBAs from LCD TVs

PCBAs from LCD TVs

**NOVA process**

**Depopulated PCBs**  
(48% mass)



<b>Metal distr.</b>	
	<b>(%)</b>
Ag	12%
Au	3%
Pd	19%
Sn	19%

**Electronic components**  
(48% mass)



<b>Metal distr.</b>	
	<b>(%)</b>
Ag	62%
Au	95%
Pd	79%
Sn	41%

**Tin concentrate**  
(4% mass)



<b>Metal distr.</b>	
	<b>(%)</b>
Ag	26%
Au	2%
Pd	2%
Sn	40%

# The NOVA process applied to PCBAs from LCD TVs

PCBAs from LCD TVs - Grades			
<i>Ag</i> [g/t]	<i>Au</i> [g/t]	<i>Pd</i> [g/t]	<i>Sn</i> [%]
513	78	12	2,0%

**NOVA process**

**Depopulated PCBs**  
(48% mass)



Depopulated PCBs - Grades			
<i>Ag</i> [g/t]	<i>Au</i> [g/t]	<i>Pd</i> [g/t]	<i>Sn</i> [%]
138	5	6	0,8%

**Electronic components**  
(48% mass)



Electronic components - Grades			
<i>Ag</i> [g/t]	<i>Au</i> [g/t]	<i>Pd</i> [g/t]	<i>Sn</i> [%]
574	136	17	1,5%

**Tin concentrate**  
(4% mass)



Tin concentrate - Grades			
<i>Ag</i> [g/t]	<i>Au</i> [g/t]	<i>Pd</i> [g/t]	<i>Sn</i> [%]
3250	36	0	19,6%

# The NOVA process applied to PCBAs

Low-grade & Mid-grade PCBAs

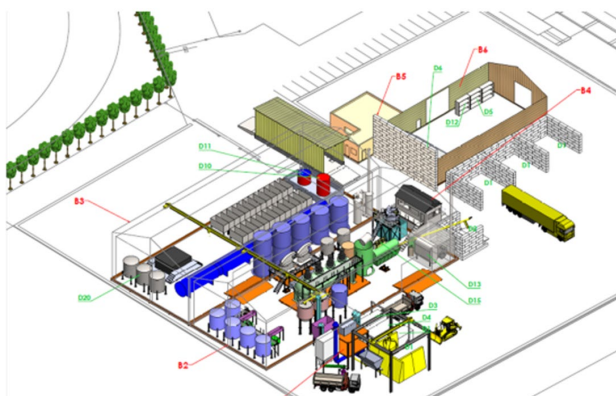
**NOVA process**

**Depopulated PCBs**

**Electronic components**

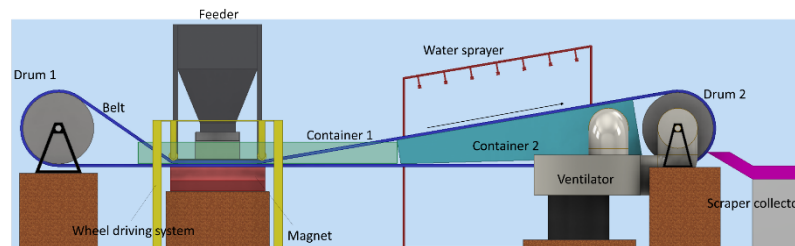
**Tin concentrate**

*BIOLIX process by Uliège and Comet Traitements for Cu recovery*



**Pyrometallurgy**

**TU Delft sorting technologies for concentration**



*Tin and PMs recovery using DES leaching by TecNALIA*





Thank you

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VIENNA, AUSTRIA

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