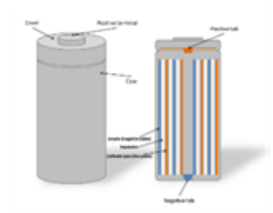
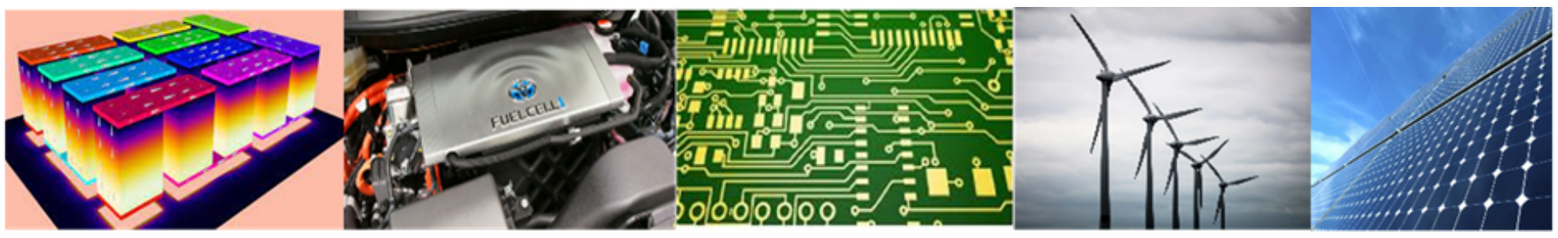
A toolbox for sustainable metal recycling

- **Sustainable energy uses metallic and semiconductor structures distributed in organic and inorganic phases**

- **Classical routes use hydro- and pyrometallurgical routes to achieve complete digestion**

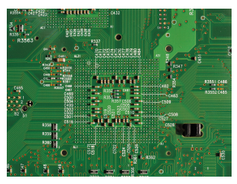
- **We can design more efficient recycling processes by targeting weaknesses in specific phases**

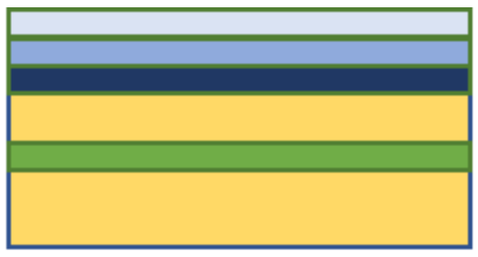




From left to right: Li-ion batteries (Li, Co), thermoelectric devices (Se, Te), Fuel cells (PGMs), Printed circuit boards (Au, Ni), Wind turbines (Nd, Dy), Photovoltaic devices (Bi, Te)

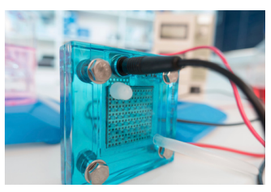
Metal	Generally reactive	Ductile
Inorganic	Generally Unreactive	Brittle
Organic	Generally unreactive	Ductile

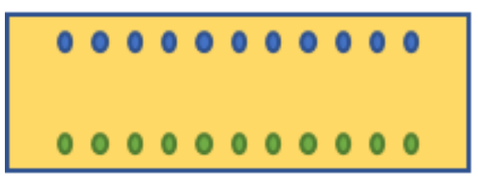




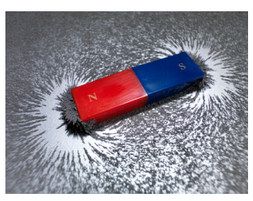
Printed circuit board

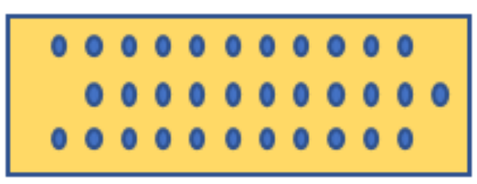
Battery electrode material



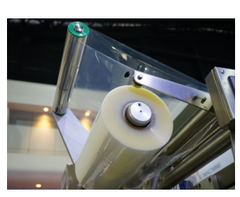


Electrolyser/ Fuel Cell

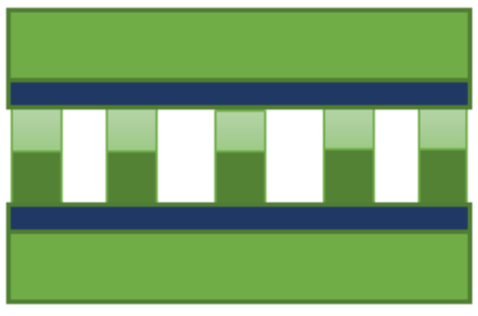




Composite magnets/ active fabric



Laminate film



Thermoelectric device

Photovoltaic device

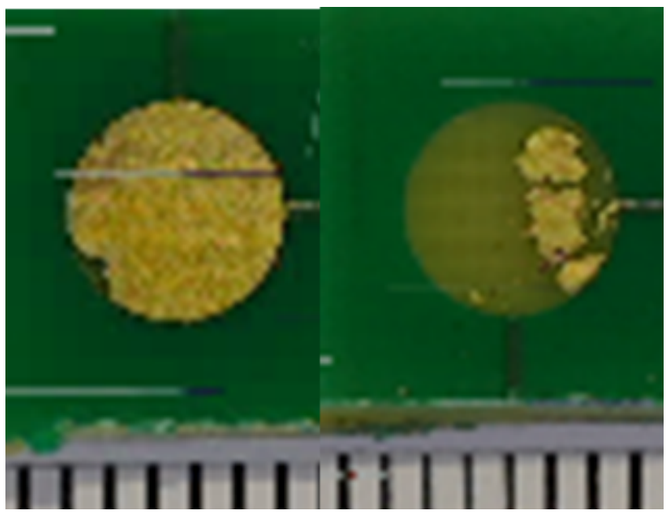
The toolkit has developed selective redox catalysts for metal digestion

Hydrogenation techniques for magnet fragmentation

Novel debondable adhesives for designed disassembly

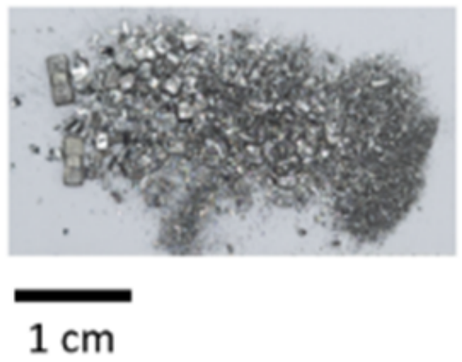
Environmentally compatible etchants to target base metals

Ultrasonic enhanced etchants to avoid passivation



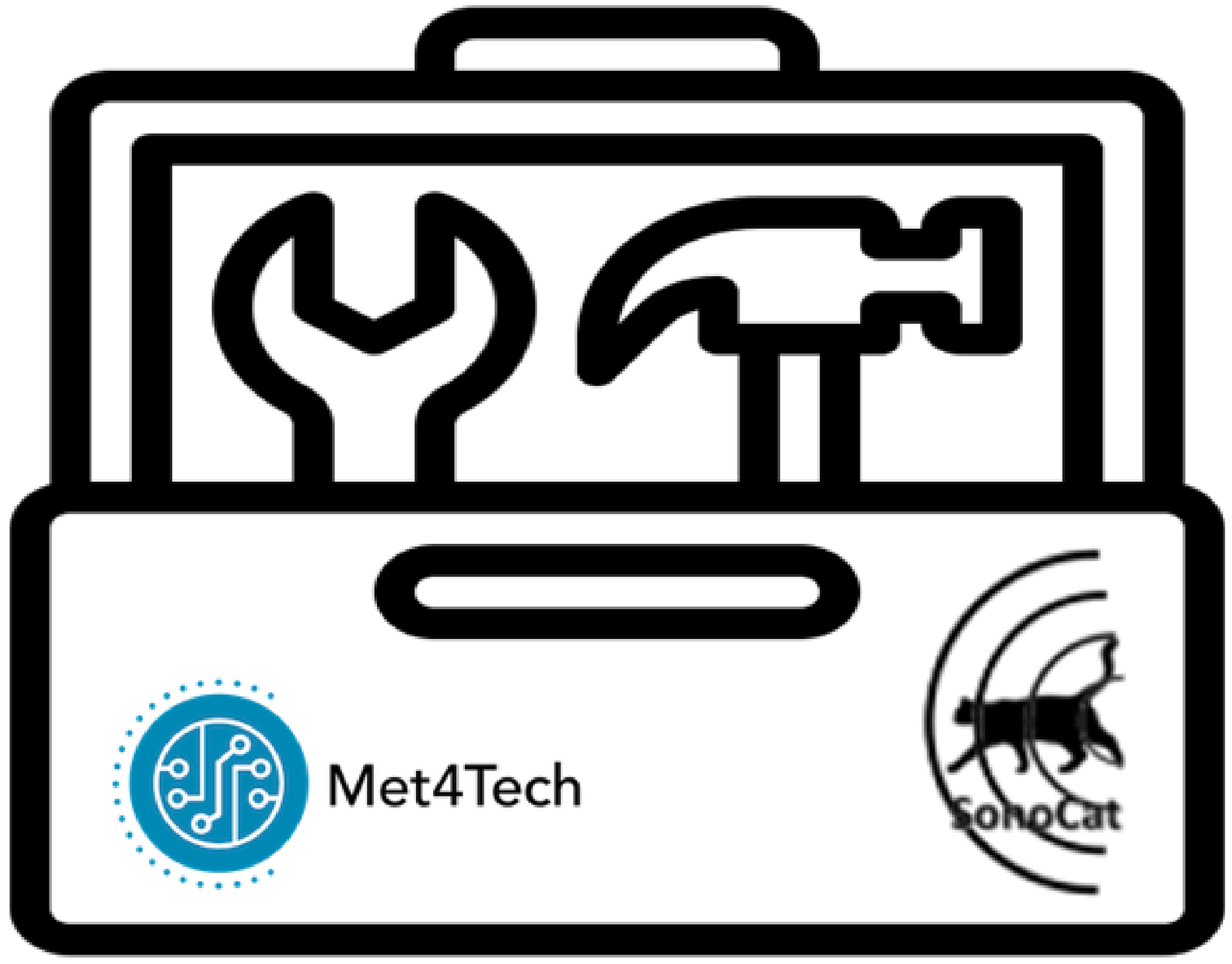
Selective dissolution with redox catalysts

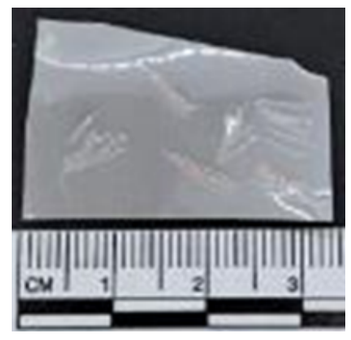
Recycling photovoltaic devices with brines



High intensity ultra-sonication for thermoelectric device recycling

Hydrogen processing of magnets

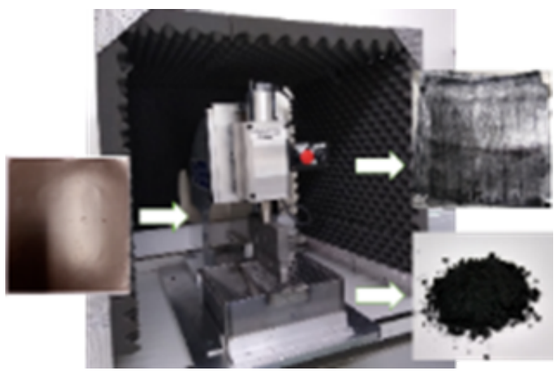




Polymer dissolution and removal

Valorisation of non-metallic fractions e.g. magnetic concrete

Electropurification of metals



Lithium ion batteries recycling/re-generation

Our partners:

European Thermodynamics Limited
Intelligent Thermal Management

BULLITT

HYPROMAG
Magnet Recycling

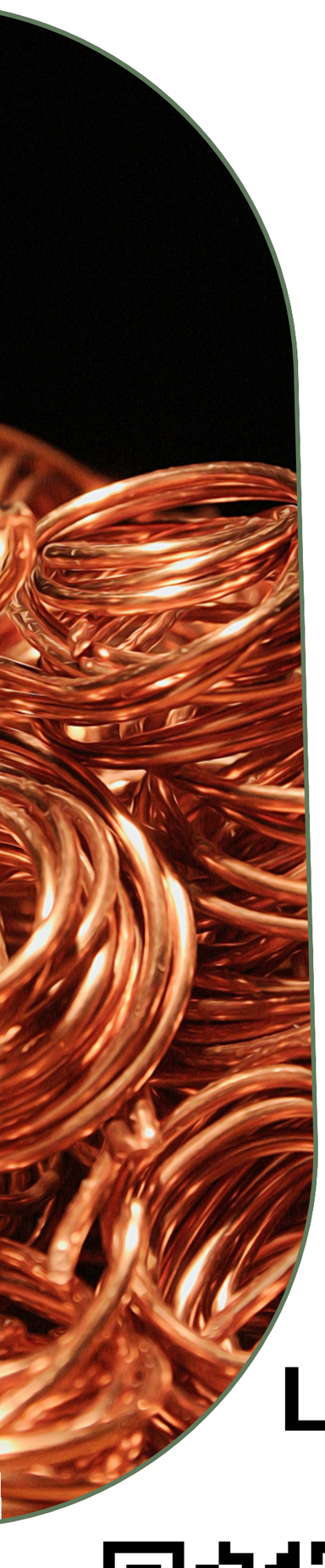
ALCHEMY METALS GROUP

sfx

CIRCULAR RESOURCES

Highlights

- **Novel solvent systems allow acid-free, selective dissolution of metals**
- **Combining physical (ultrasounds) and chemical (selective oxidation) leads to fast and highly efficient processes**
- **Successfully applied to Li-ion batteries, PCBs, thermoelectric materials, solar cells, magnets**
- **Specific waste need specific process: polymer dissolution/removal, valorisation of low-value materials, hydrogen processing of magnets**
- **Processes informed by LCA, TEA, design for recycle and process automation**



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