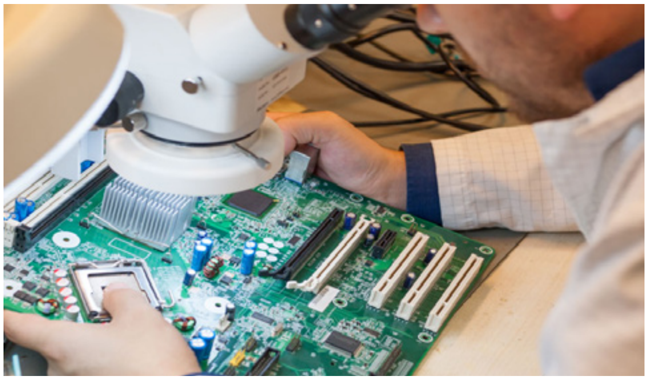
SEPARATION TECHNOLOGY FOR COMPLEX METAL STREAMS

A multistep process extracts base and precious metals from circuit boards and purifies them for reuse.



Waste printed circuit boards (WPCB) contain precious metals such as palladium and gold, an unharvested value estimated to be upwards of $60 million.[1] The process of recovering these metals, however, currently involves multistage processes that are energy- and resource-intensive, consuming chemicals and creating toxic emissions.

Researchers at The Pennsylvania State University (Penn State) have developed a low-cost, efficient, and environmentally sustainable process to recover base and precious metals from WPCB. Their multi-stage process integrated heat-based chemical decomposition (thermolysis)to first remove all the organics and then employed, mechanical and chemical separations, along with the pioneering use of nanocrystalline cellulose for selective separation of metal ions.

The approach not only achieved high recovery efficiencies for valuable metals such as copper, gold, silver, and palladium but also introduced a novel, environmentally friendly method for metal separation.

PROJECT DESCRIPTION

The 12-month project created a process to separate valuable metals from waste printed circuit boards. The project began with Industrial partner CHZ Technologies shredding and treating the circuit boards with a pilot-scale thermolysis process. The thermolysis converted the organics in the circuit boards WPCB to fuel gas and produced a char-metal mixture.

The research team at Penn State then comprehensively characterized the char-metal mixture for potential recovery of base and precious metals. Next the components in the char-metal mixture were separated into various particle size distributions.

using low-cost physical methods including gravity-based and magnetic separation. The resulting product streams were then subjected to a three-stage selective chemical process. In the first stage, base metals were selectively leached using sulfuric acid and hydrogen peroxide. The second stage targeted gold and silver with a thiourea leaching process, and the third stage used chloride leaching to recover palladium. This phase resulted in more than 98% recovery of copper and aluminum in the first step, more than 96% recovery of gold and silver along with 5% palladium recovery in the second step, and 84% palladium recovery in the last step.

The products from each step of the process were then purified to extract high-purity base and precious metals using patented, chemical-free ozone oxidative precipitation process extracted a critical elements mixture of cobalt, nickel, and manganese that could be further refined.

PROJECT IMPACT

By utilizing a thermolyzer process for initial treatment followed by physical separation and staged selective separation with lower-impact chemicals, this process minimizes the energy consumption (primarily associated with grinding materials in conventional processes) and the environmental concerns of commonly used reagents like cyanide.

[1] D'Adamo, I., Ferella, F., Gastaldi, M., Maggiore, F., Rosa, P., and Terzi, S. 2019. "Towards sustainable recycling processes: Waste printed circuit boards as a source of economic opportunities." Resources, Conservation and Recycling. October 2019. Vol. 149, 455–467. https://doi.org/10.1016/j.resconrec.2019.06.012

RECYCLING & RECOVERY

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The project also introduced several technological innovations, including the use of efficient physical separation techniques, and nanocrystalline cellulose for enhancing final product purity.

NEXT STEPS

The team shared project findings through peer-reviewed publications, conference presentations, and poster presentations. The project also contributed to workforce development by engaging a diverse group of post-doctoral researchers and students at the PhD, master's, and undergraduate level. Continued research and industry partnerships could optimize the process efficiency, assess cost-effectiveness, enhance recovery rates, and explore integration with existing recycling infrastructure.

PROJECT PARTNERS

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PUBLICATIONS

Rezaee, M., Sheikhi, A., Pisupati, S., and Hickner, M. 2024. Development and Validation of Metal Separation Technology for Complex Metal Systems: Final Report for REMADE Project: 19-01-RR-12. January 2024.

Rezaee, M. 2023. Apparatus and Process for Selective Liberation and Mechanical Recycling of Electronic Waste to Recover Valuable Elements. Provisional patent (U. S. Serial No. 63/519,376).

FOR MORE INFORMATION

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