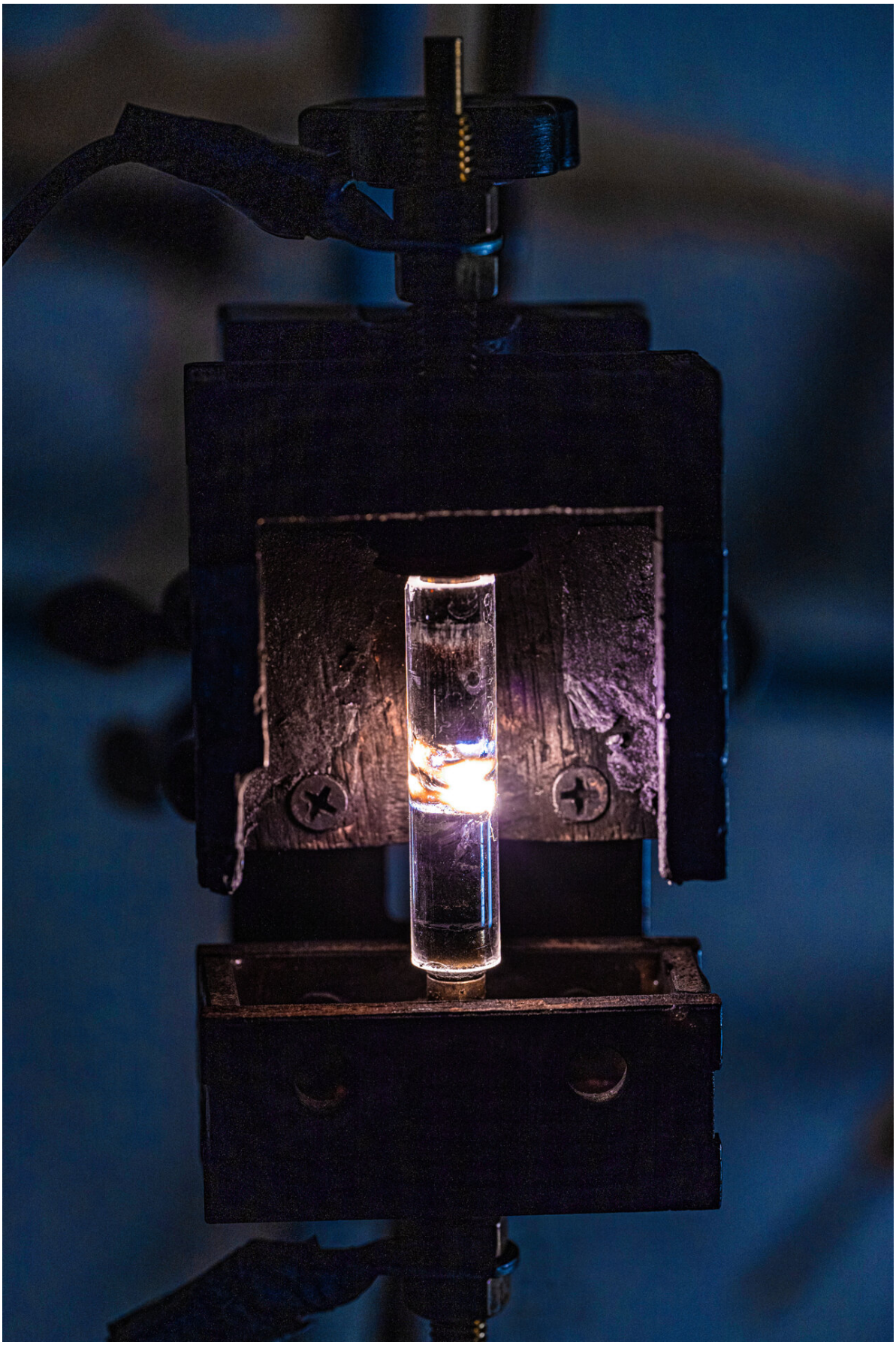
Urban mining for metals flashes forward

October 4 2021



The flash Joule heating process developed at Rice University has been adapted to recover valuable and toxic metals from electronic waste. The process allows for “urban mining” of resources that could be a win for the environment as well as for manufacturers. Credit: Jeff Fitlow/Rice University

In what should be a win-win-win for the environment, a process developed at Rice University to extract valuable metals from electronic waste would also use up to 500 times less energy than current lab methods and produce a byproduct clean enough for agricultural land.

The flash Joule heating method introduced last year to produce graphene from carbon sources like waste food and plastic has been adapted to recover rhodium, palladium, gold and silver for reuse.

A report in *Nature Communications* by the Rice lab of chemist James Tour also shows highly toxic heavy metals including chromium, arsenic, cadmium, mercury and lead are removed from the flashed materials, leaving a byproduct with minimal metal content.

Instantly heating the waste to 3,400 Kelvin (5,660 degrees Fahrenheit) with a jolt of electricity vaporizes the precious metals, and the gasses are vented away for separation, storage or disposal. Tour said that with more than 40 million tons of e-waste produced globally every year, there is plenty of potential for "urban mining."

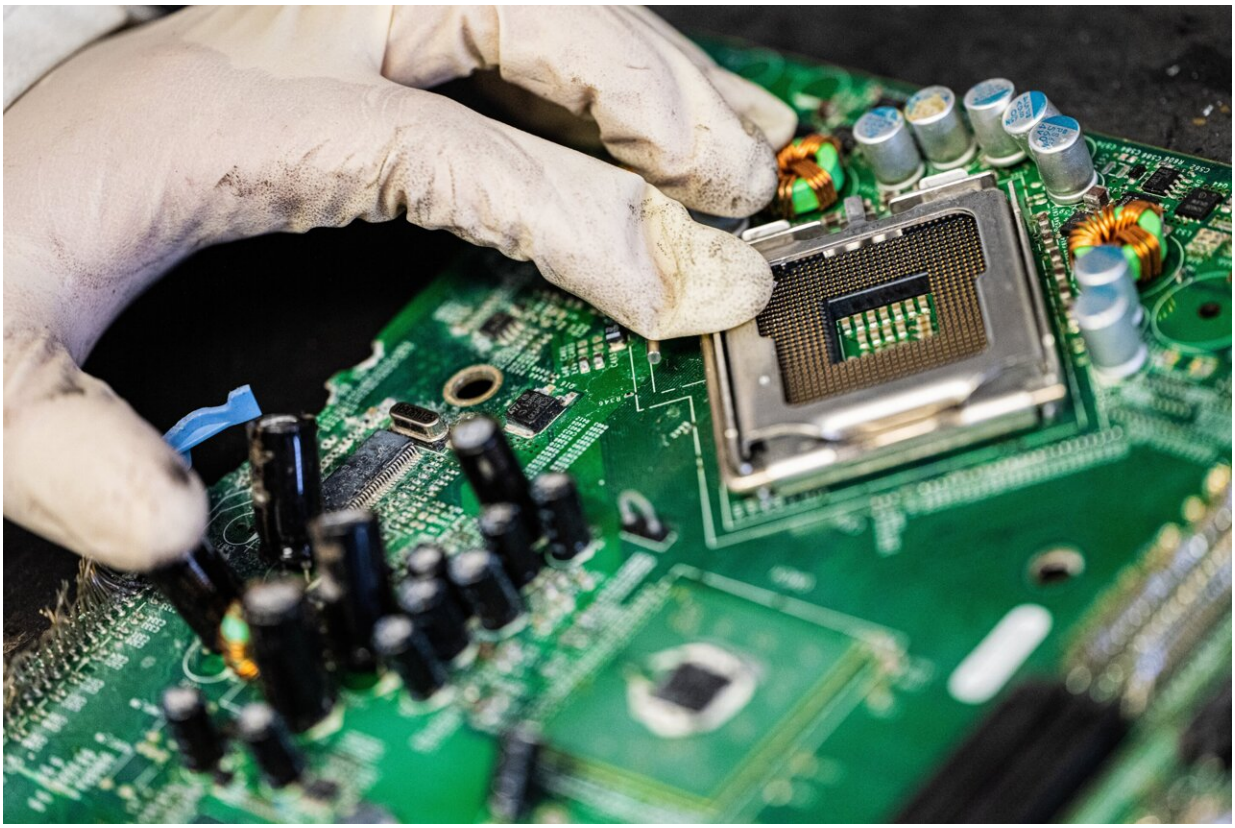
"Here, the largest growing source of waste becomes a treasure," Tour said. "This will curtail the need to go all over the world to mine from ores in remote and dangerous places, stripping the Earth's surface and using gobs of water resources. The treasure is in our dumpsters."

He noted an increasingly rapid turnover of personal devices like cell phones has driven the worldwide rise of electronic waste, with only about 20% of landfill waste currently being recycled.

"We found a way to get the precious metals back and turn e-waste into a sustainable resource," he said. "The toxic metals can be removed to spare the environment."

Rice University chemist James Tour, left, and postdoctoral research associate Bing Deng prepare to “flash” electronic waste to recover its valuable metals for recycling. The lab’s process, first developed to turn waste food and other carbon sources into graphene, has been adapted to recover other materials. Credit: Jeff Fitlow/Rice University

The lab found flashing e-waste requires some preparation. Guided by lead author and Rice postdoctoral research associate Bing Deng, the researchers powdered circuit boards they used to test the process and added halides, like Teflon or table salt, and a dash of carbon black to improve the recovery yield.

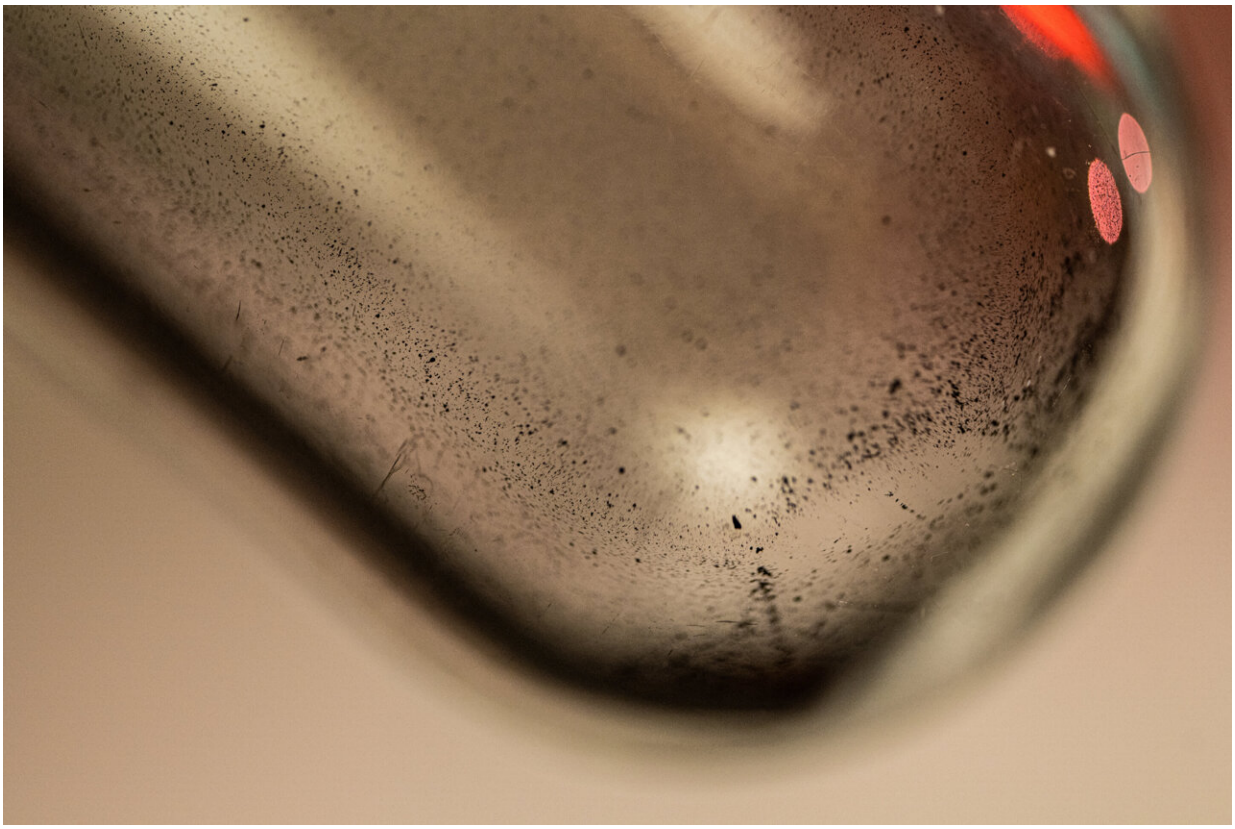


A flash Joule heating process developed at Rice University recovers valuable and toxic metals from electronic waste. The process allows for “urban mining” of resources. Credit: Jeff Fitlow/Rice University

Once flashed, the process relies on "evaporative separation" of the metal vapors. The vapors are transported from the flash chamber under vacuum to another vessel, a cold trap, where they condense into their

constituent metals. "The reclaimed metal mixtures in the trap can be further purified to individual metals by well-established refining methods," Deng said.

The researchers reported that one flash Joule reaction reduced the concentration of lead in the remaining char to below 0.05 parts per million, the level deemed safe for agricultural soils. Levels of arsenic, mercury and chromium were all further reduced by increasing the number of flashes.



Metals settle at the bottom of a vial after being separated from other components in a crushed circuit board through flash Joule heating. The process developed at Rice University could lead to “urban mining” for valuable metals from electronic waste. Credit: Jeff Fitlow/Rice University

"Since each flash takes less than a second, this is easy to do," Tour said.

The scalable Rice process consumes about 939 kilowatt-hours per ton of material processed, 80 times less energy than commercial smelting furnaces and 500 times less than laboratory tube furnaces, according to the researchers. It also eliminates the lengthy purification required by smelting and leaching processes.

More information: Deng, B. et al. Urban mining by flash Joule heating. *Nat Commun* (2021). doi.org/10.1038/s41467-021-26038-9

Provided by Rice University