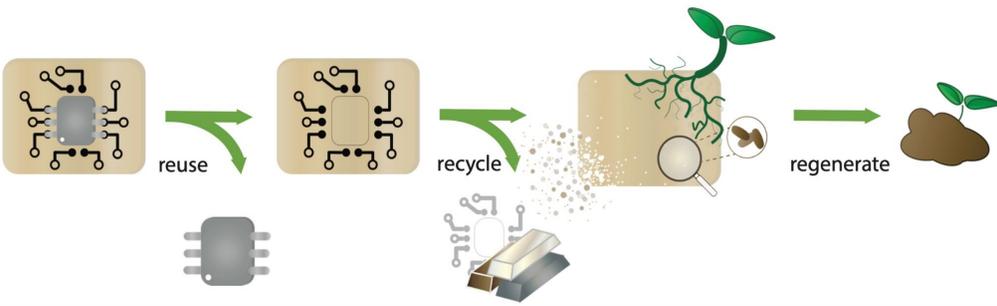


Introduction



We present a design guideline and a digital fabrication process to build circuits on biodegradable substrates that reduce embodied carbon and toxic waste.

We built a working prototype of a sustainable computer mouse with a biodegradable circuit board and case.

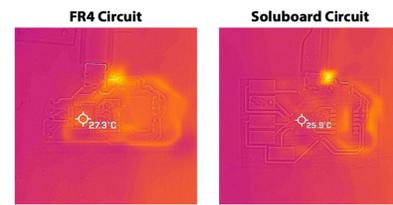
Design Guidelines

- 1) Reduce silicon:** IC production dominates a device's manufacturing carbon footprint. We minimize the number of chips by selecting highly integrated systems-on-chip (SoCs).
- 2) Improve circularity:** We can further reduce carbon footprint by removing general purpose chips like microcontrollers from PCBs and reusing them.
- 3) Incorporate biodegradability:** We use environmentally friendly, biodegradable materials wherever possible to make parts like the PCB substrate and enclosure.
- 4) Evaluate environmental impacts:** We perform a life cycle assessment (LCA) to estimate environmental impacts of our design used for steering decisions towards lower environmental impact options.

Performance

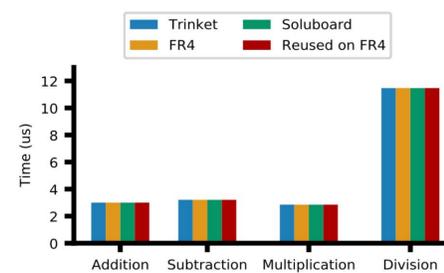
Thermal Performance

Temperature of mouse circuits on standard FR4 and biodegradable material.

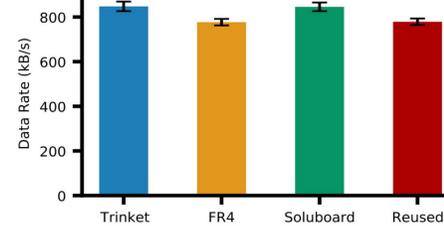


Computing Benchmarks

Benchmark results show chips work on different materials before and after reuse.



USB Speed Tests show rates >750 kbps for each prototype including reused chips.



Disposal

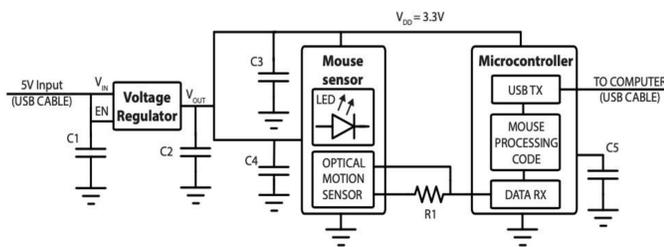


Dissolving circuit in water: The circuit board (Soluboard, made of flax fibers) and PVA case can dissolve in water. A recovered chip is baked at in an oven to remove moisture and reused with no signs of performance loss.

Fabrication

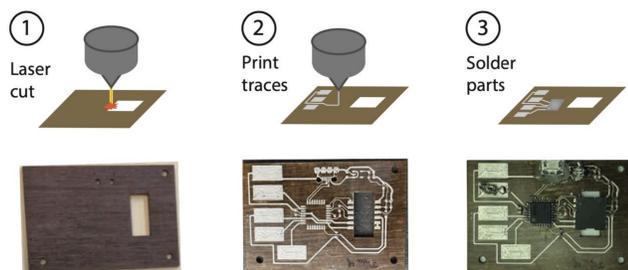
Mouse circuit

Circuit diagram of components in our mouse design.



Biodegradable PCB fabrication

Process of making PCBs on biodegradable materials.

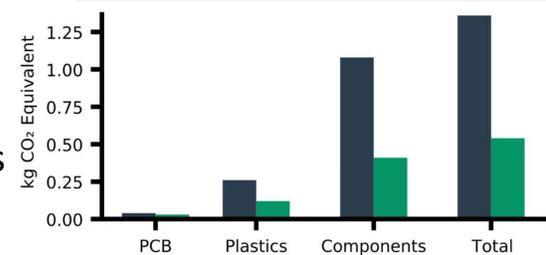


Environmental Impact Evaluation

Carbon footprint comparison

Overall design reduces the e-waste of the device and enables easy reclamation and reuse of components, avoiding further emissions from producing virgin components.

Design	kg CO ₂ Equivalent			Total
	PCB	Plastics	Components	
Commercial	0.02	0.26	1.08	1.36
Ecofriendly	0.01	0.12	0.41	0.54



Future Work

Inverse design for materials discovery, modular PCBs, novel fabrication methods

