Sustainable Electronics

Tackling Tomorrow's E-Waste through Design

S. Beasley[1], A. Bruce[1], K. Crews[2], M. Johnston[1], M. Kammer[1], M. McCoy[1], G. Mendis[1], S. Peng[1], V. Powell-Rose[2], E. Triggs[2], A. Vedantam[1]

[1]Purdue University , West Lafayette, IN 47907
[2] Tuskegee University, Tuskegee, AL 36088

How can we reduce the impact of future electronic waste?

The amount of **e-waste is growing rapidly**, and is expected to only increase in the future as newer, faster electronic products continually render old ones obsolete. Due to unique properties of e-waste **it is critical to manage the end-of-life stage** to reduce environmental contamination, adverse effects on human health, and wasted resources. This is done through **better technology, policy, and management design**.

1) Increasing material efficiency

Incorporating **crystalline nanocellulose** into plastics can improve their mechanical and thermal properties. This means that less material can be used for the same application. Another way to increase material efficiency is to decrease failure rates, done through using **self healing polymers** based on a biological blueprint.

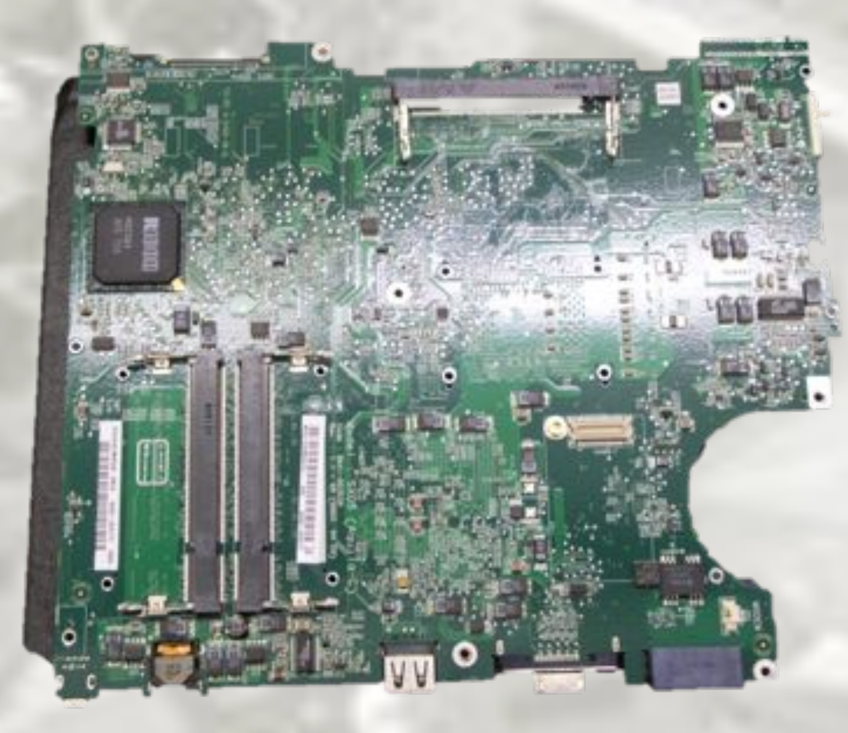

Figure 1: A printed circuit board (PCB) from a disassembled laptop. Tetrabromobisphenol A (TBBPA) is a BFR that is used in 90% of PCBs. The long term health effects of TBBPA on humans is uncertain, but known to bioaccumulate in people and the environment.

2) Replacing toxic materials

Brominated flame retardants (BFRs) are coming under increased interest by the public as a substance of concern. The fire retardant and mechanical properties of **epoxy/nanoclay** and **epoxy/lignin** composites are being measured to determine their suitability for use in PCBs. **Life cycle analyses** (LCAs) are being conducted to find out if these materials are more environmentally sustainable than the current product.

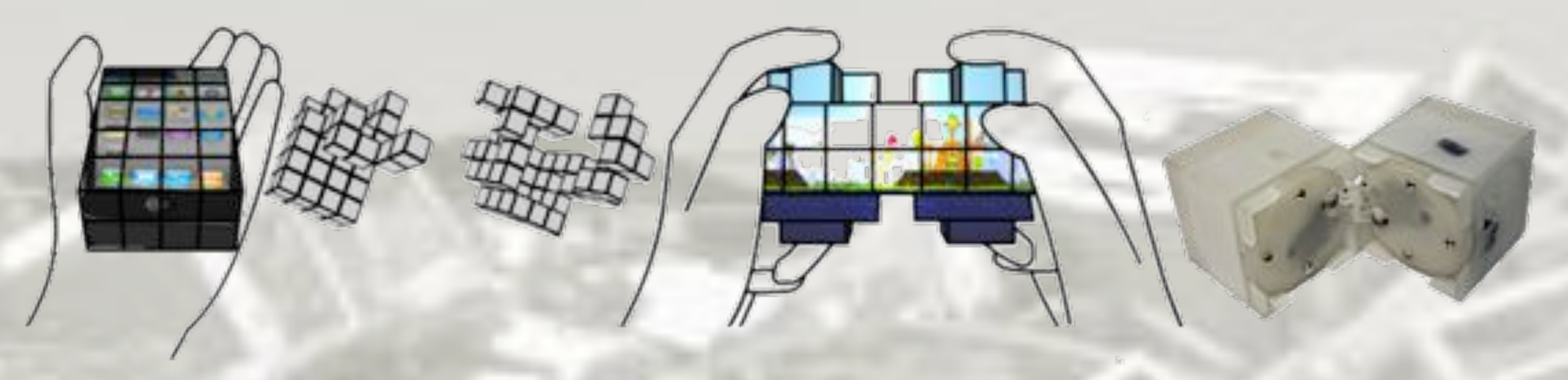

Figure 2: A device being created by M. McCoy to reduce the number of monitors necessary for different devices – using one modular cube based design for everything. Environmental impacts of 3D printing such a device will be quantified using life cycle analysis methodology.

3) Using natural materials

Natural materials offer an excellent choice to replace petroleum and non-biodegradable based products. Some challenges are to find optimal uses for natural fiber and to address known challenges like a high degree of moisture absorption and poor thermal stability. **Cellulose** and **jute fibers** are being investigated as fiberglass replacements – increasing the sustainability of whatever product they are incorporated into.

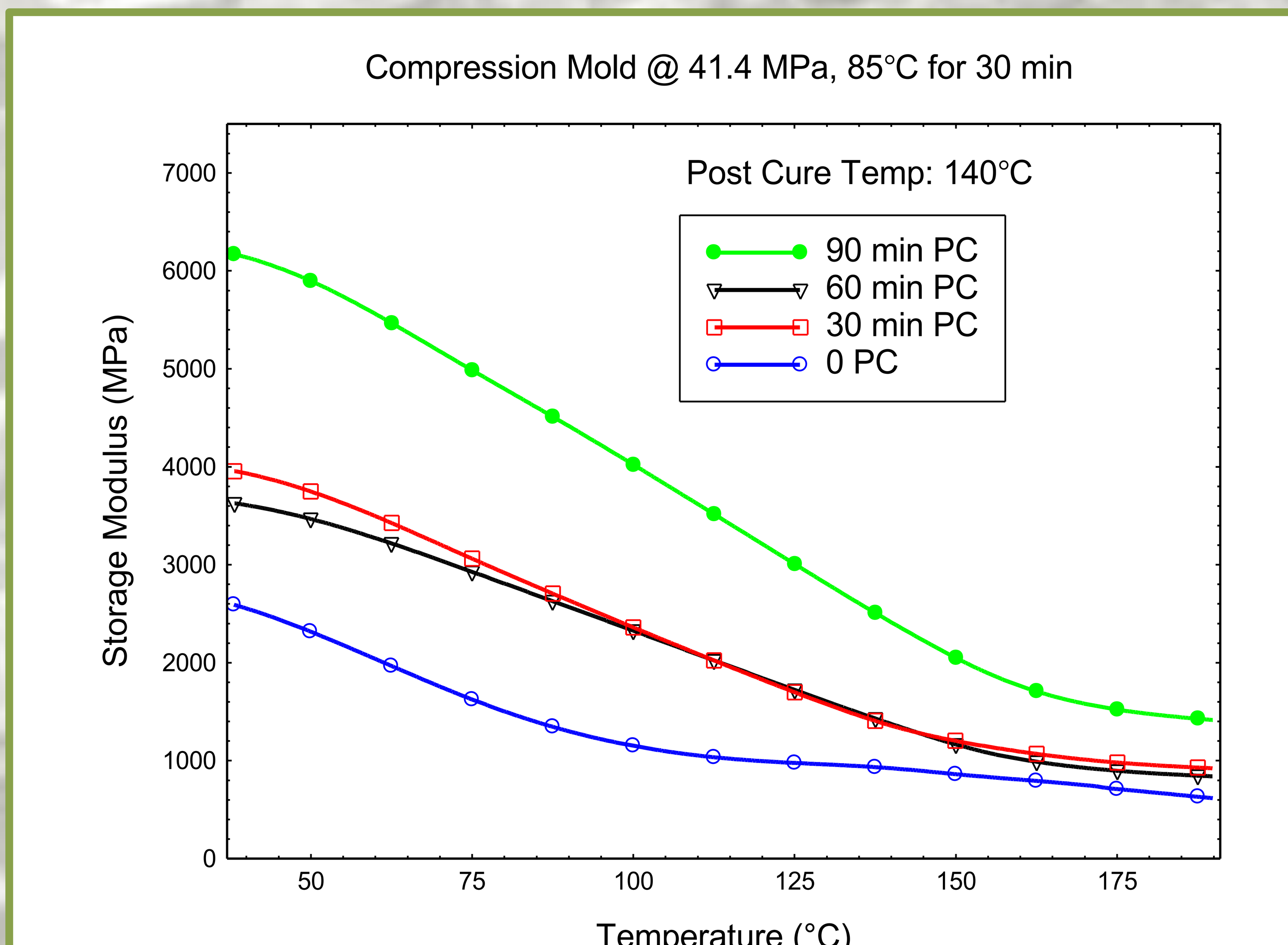

Figure 3: Dynamic mechanical analysis of jute fiber composite samples infused with soybean oil based polyester resin and initiated with a nitroxide mediated hydroperoxide. Boards were made and tested by E. Triggs with varying post cure cycles. The glass transition temperature was found to increase by 18°C allowing this sustainable material to be used in more demanding applications.

4) Thinking outside the box

Unique design solutions exist for some of the more challenging problems in electronics, such as the **increasing amount** of electronics in use today and issues surrounding **solder.** Creating **modular devices** that can be used in many different applications could reduce the number of electronic devices in use. **Copper/silver core/shell particle** technology has been shown to be a viable drop-in solder replacement. This low-processing-temperature system minimizes energy consumption and material related sustainability issues relating to traditional lead-based and lead-free solders.

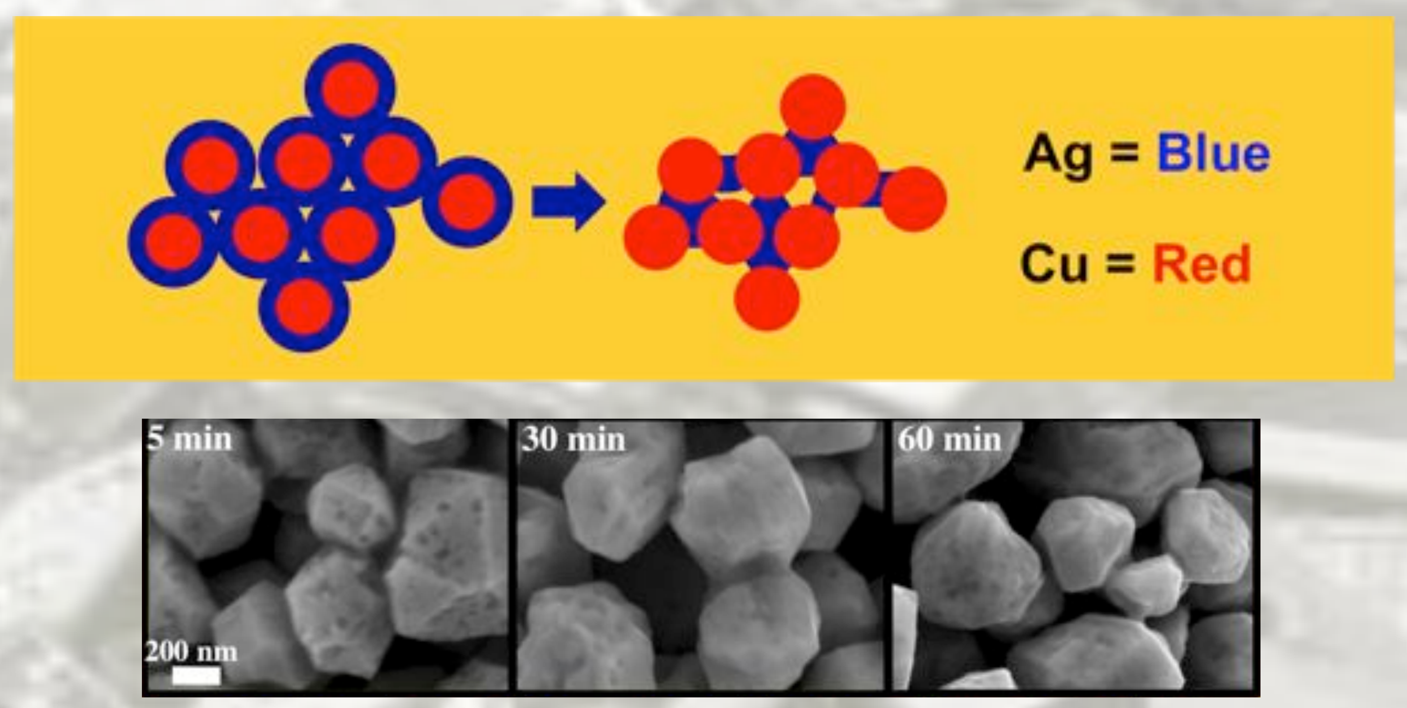

Figure 4: A schematic and SEM image of the interconnect formation process of copper/silver core/shell particles fabricated by M. Kammer. This process occurs at lower temperatures than traditional soldering, leading to increased energy efficiency and lower thermal requirements for plastics used surrounding interconnects.

5) Including diverse stakeholders in the process.

These technological solutions result in more sustainable and recyclable products, but without **changes in public policy and business practices** the products will continue to be landfilled. Research into the **reverse supply chain** of recycled goods and the **voluntary policies** that regulate recyclers will search for optimal solutions that will be effective in the real world.

Acknowledgements

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