Microfactory Technologies

Transforming Waste into Value Added Materials and Products

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Research Focus: Cutting edge sustainable materials & processes
Emphasis: Environmental, Social & Economic benefits

Recycling and Materials Transformations

Sustainability of materials processes

New Technologies and Products

Green Manufacturing and Translational Research

Industry and Research partnerships

The SMaRT Centre Overview

Materials and Associated Challenges

- Waste Glass
- Polymer Waste
- E-waste
- Batteries
- Textile Waste
- Food Packaging
- Social and Economic Challenges

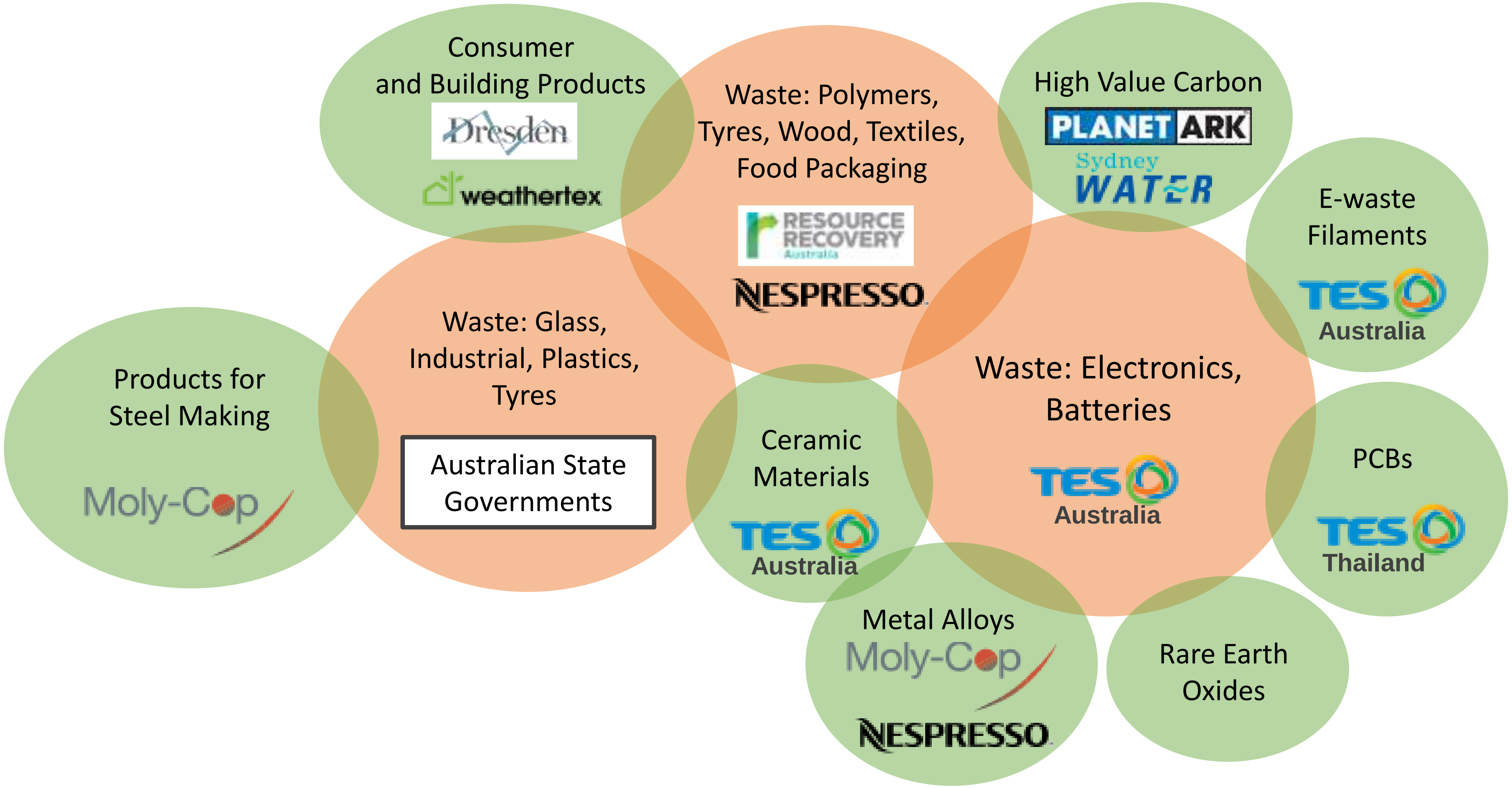
→ **Fundamentals of Materials Transformation and Recycling**

→ **New Green Solutions (Materials, Products and Technologies)**

→ **Pilot Trials and Commercialisation**

The Science of Microrecycling:

Selective Synthesis of Materials from Waste



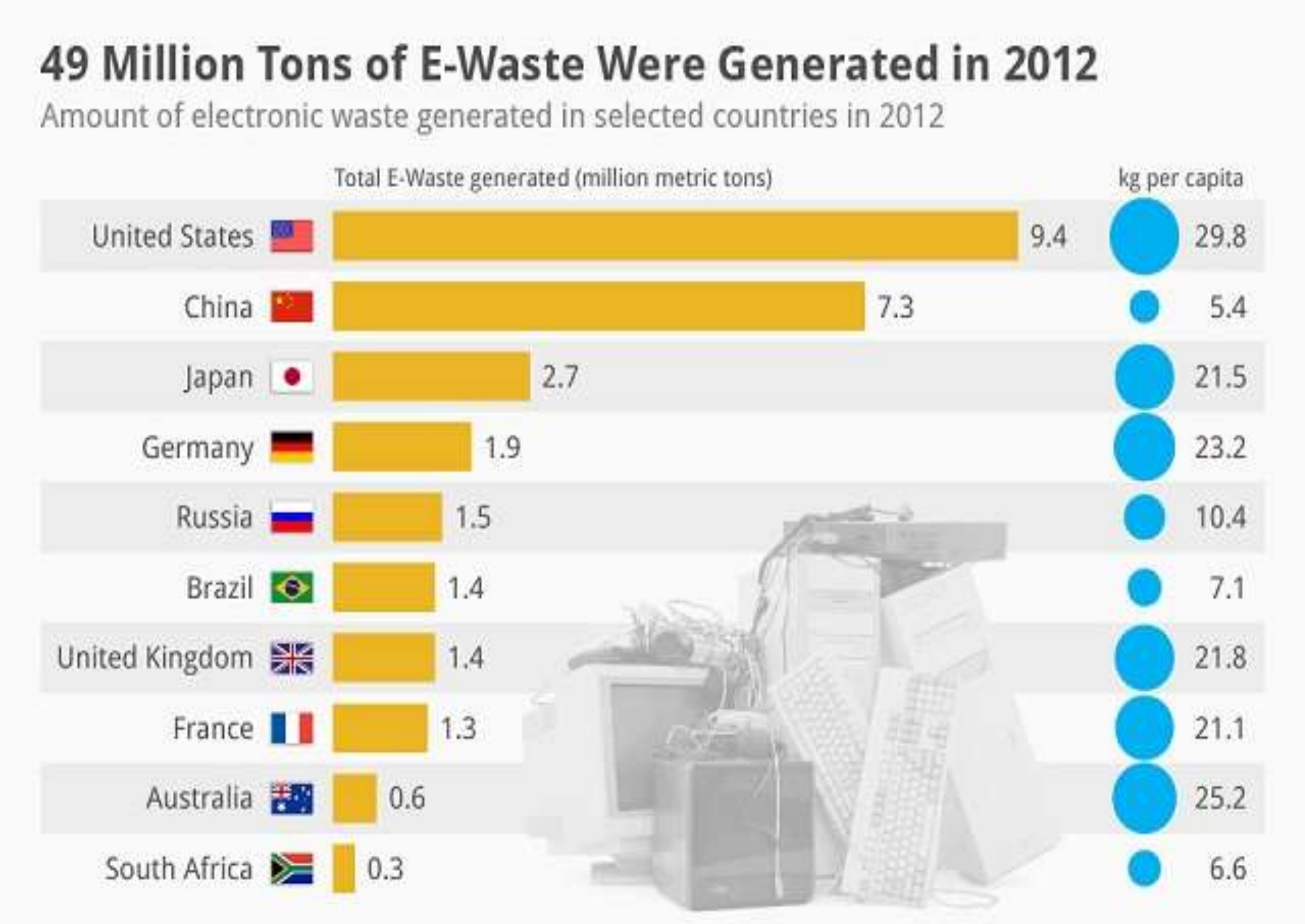
Electronic Waste (E-Waste)

- Electronic waste covers a wide range of end-of-life electric and electronic equipment considered obsolete by their users
- It is the fastest growing waste stream, increasing from 3% to 5% every year
- 400-700 million computers will be generated in developing countries by 2030

Each year around 50 million tones of e-waste are produced



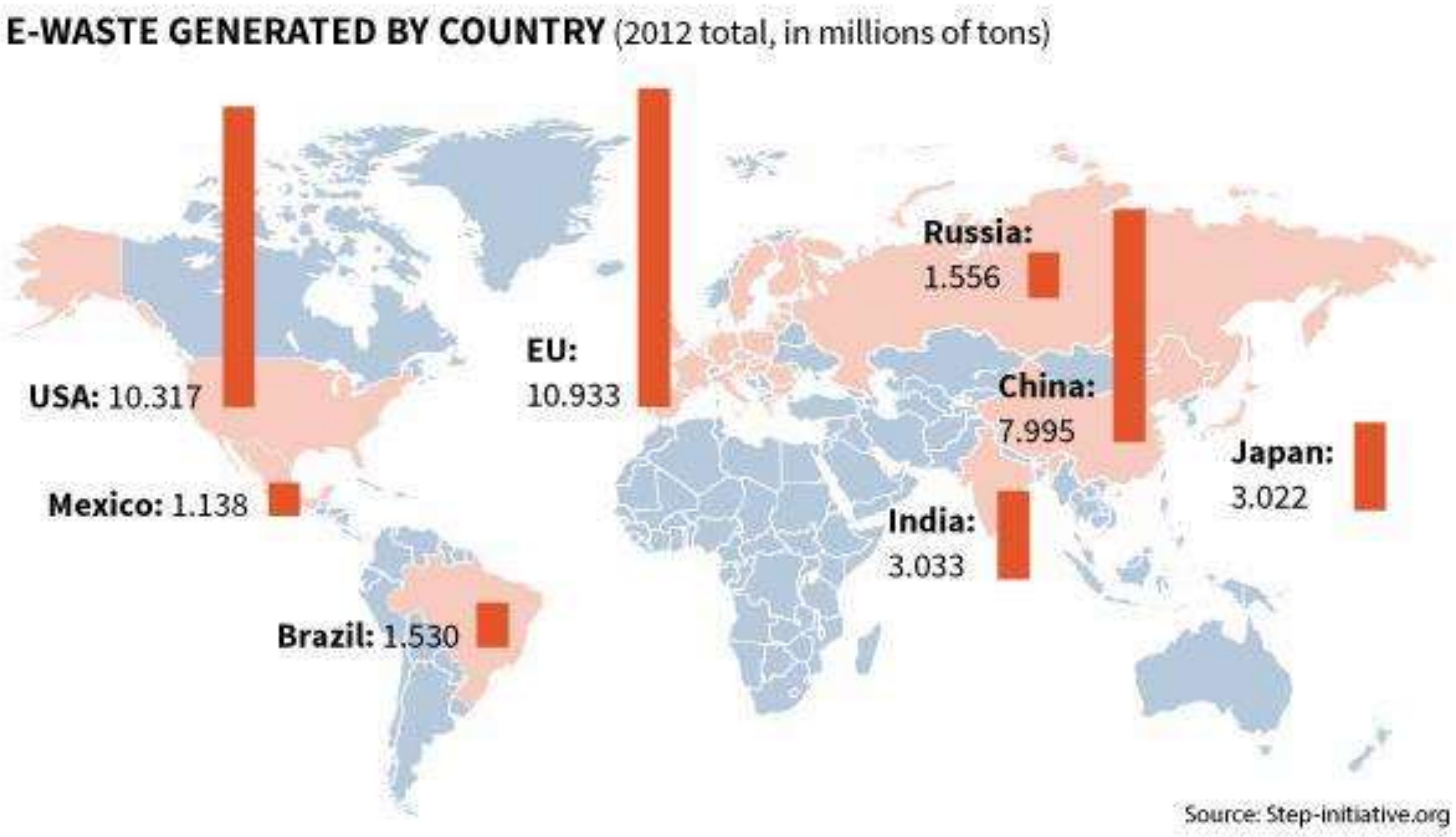
Electronic Waste



In 2012 world electronic equipment production was $2.15 trillion[1] of which 25% was related to computer production and more than 27% was communication equipment.

Ref: https://www.ttieurope.com/docs/IO/29785/20130929.pdf

E-waste Generation



Are we experiencing an E-Waste Tsunami? E-Waste Management in Mysore, India - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/e-waste-generation-by-country-2012-total-in-millions-of-tons_fig1_320740271 [accessed 12 Dec, 2018]

The E-waste Challenge & Opportunity

E-waste generated in 2014 contained nearly **$70 billion** worth of embedded resources.

In Australia, **4 million computers** are expected to be sold every year and **less than 1.5 %** will be recycled

PCBs typically contain 40 wt% metals, 30 wt% organics and 30 wt% ceramics

Printed Circuit Board

30% ceramics

30% polymers

40% metals

Silver

Gold

Palladium

Cu 10-20%

Carbon

Sources: Schluep, M, Hagelueken, C, Magalini, R, Maurer, C, Meskers, C, Mueller, E & Wang, F 2009, *Recycling - From E-Waste to Resources*.
Cui, J & Zhang, L 2008, 'Metallurgical recovery of metals from electronic waste: A review', *Journal of Hazardous Materials*, vol. 158, no. 2–3, pp. 228-56

From Waste to Resources

An opportunity not to be wasted

Microfactories: Manufacturing ‘green materials’ from waste locally

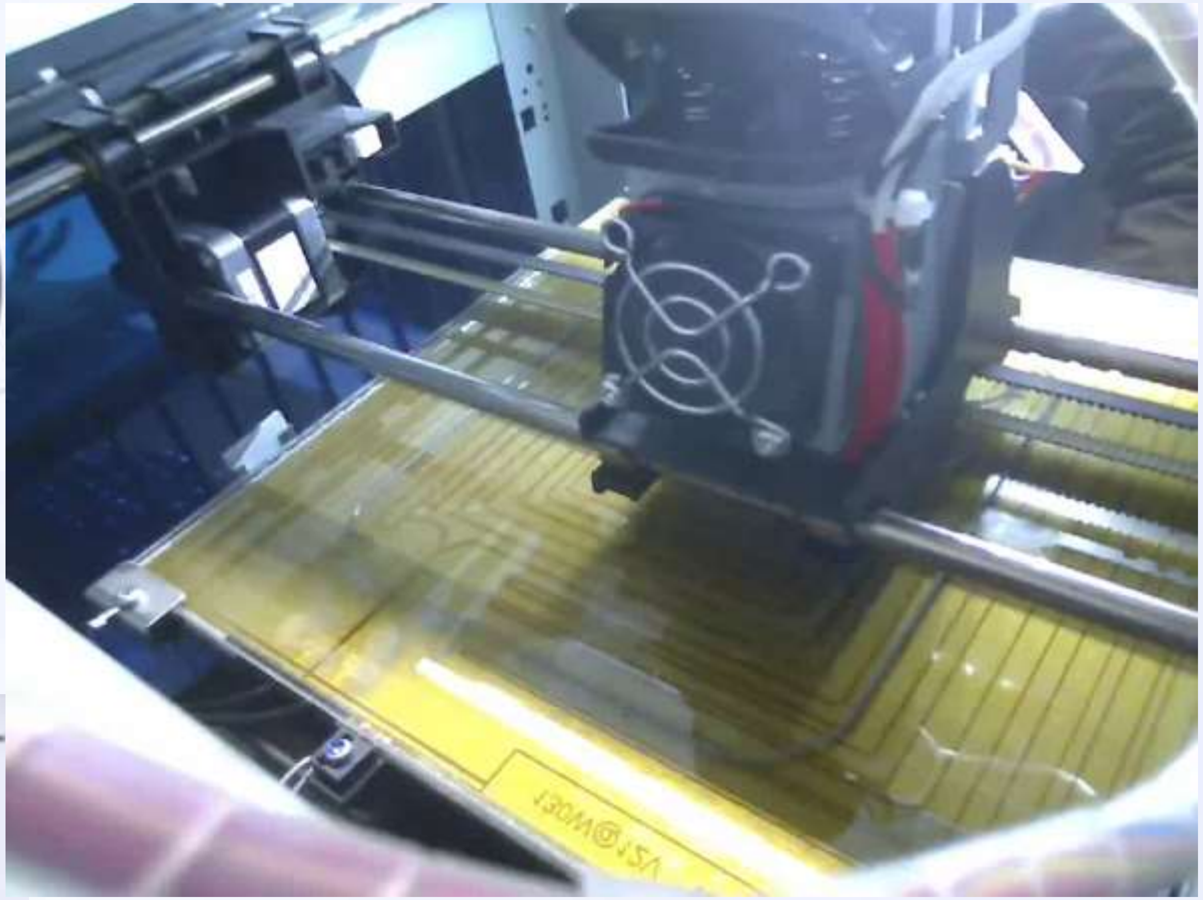
SMaRT Materials for value-added high-end applications


Microfactory
BAILEY

The Microfactory Vision

- Convert waste materials into value-added materials
- Promote and support viable local economies and jobs
- Market an Australian solution to a rapidly growing international problem
- Establish how microfactories could work in the global value chain

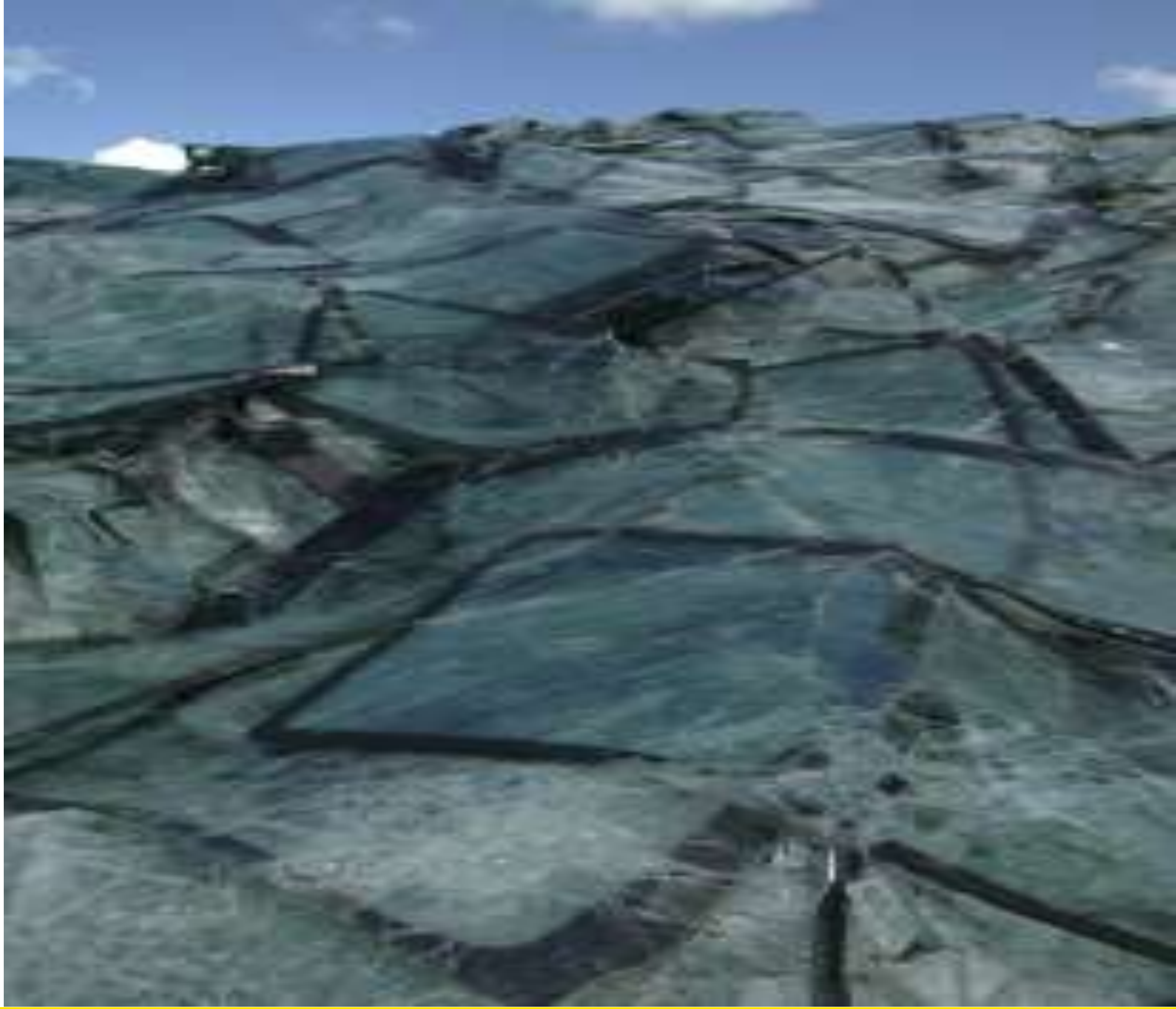
Conversion of E-waste Plastic into 3D Printed Products



Transformation of E-Waste Plastics into Sustainable Filaments for 3D Printing
Vaibhav Gaikwad, Anirban Ghose, Sagar Cholake, Aditya Rawal, Mei Iwato, and Veena Sahajwalla
ACS Sustainable Chemistry & Engineering **Article ASAP**
DOI: 10.1021/acssuschemeng.8b03105

R&D from multiple waste streams

Glass Waste



Generation of Copper Rich Metallic Phases

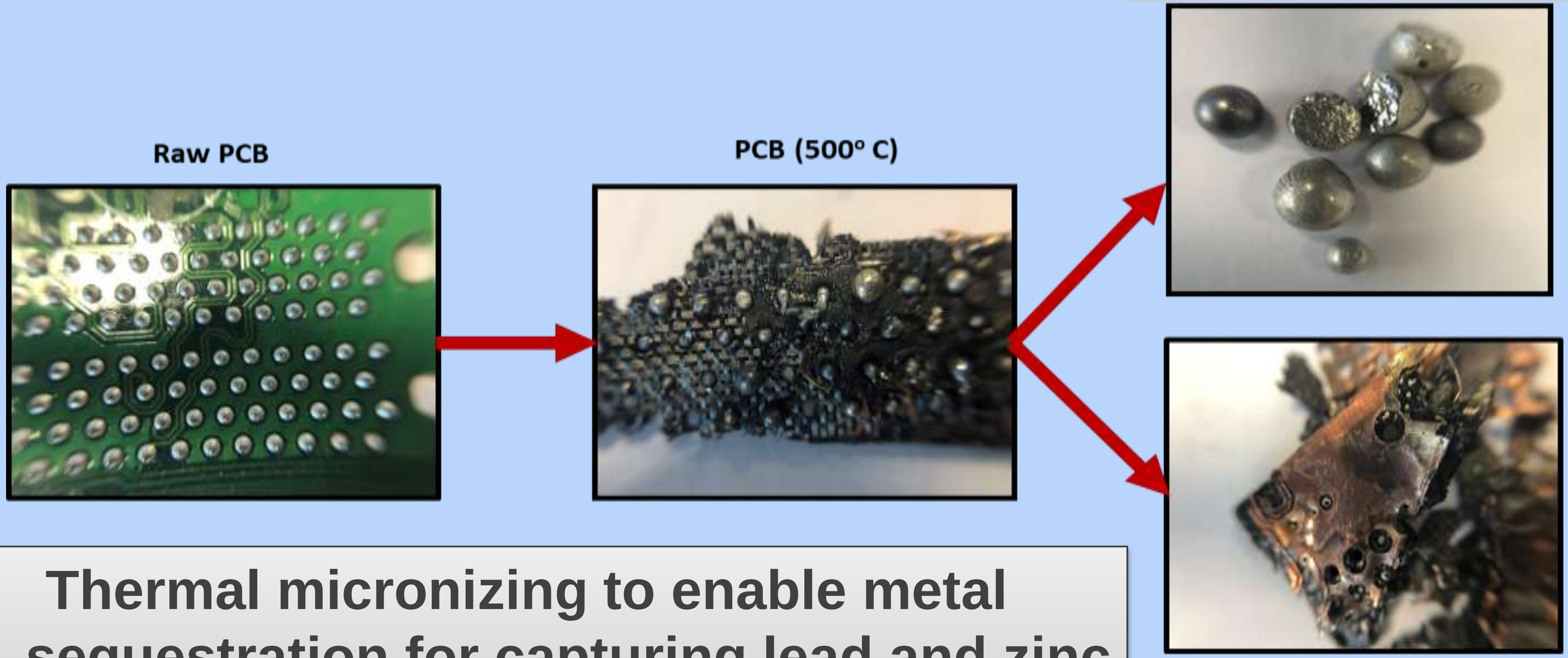
R. Cayumil, R. Khanna, M. Ikram-Ul-Haq, R. Rajarao, A. Hill, and V. Sahajwalla, “Generation of copper rich metallic phases from waste printed circuit boards,” *Waste Manag.*, vol. 34, no. 10, pp. 1783–1792, 2014.

Formation of Sn alloy from PCB

Sn-8%Zn 3.1%Pb

Raw PCB

PCB (500° C)



residue

Thermal micronizing to enable metal sequestration for capturing lead and zinc in the tin based metal alloy

Formation of Cu-alloy from PCB

Around 90% Copper

Producing copper alloy via thermal micronizing

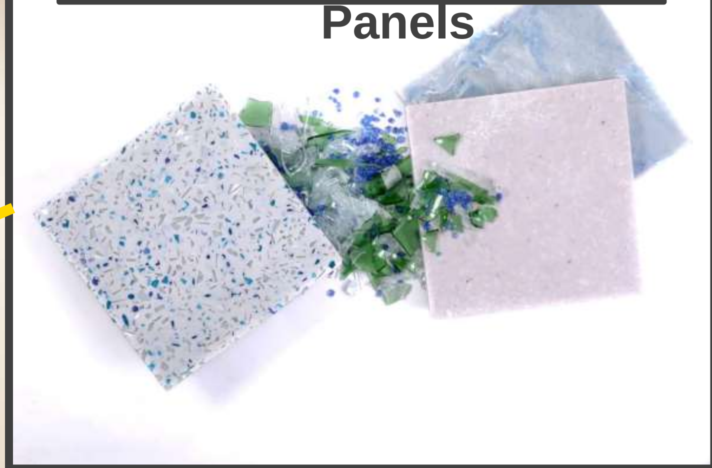
Introduced a 4th R, *reform*

- The traditional 3 R’s – Reduce, Reuse, Recycle – cannot cope with the complexity and volume of waste generated
- Need to reimagine and innovate in our approach to waste management
- Waste to value: end-of-life materials are transformed into value-added green materials

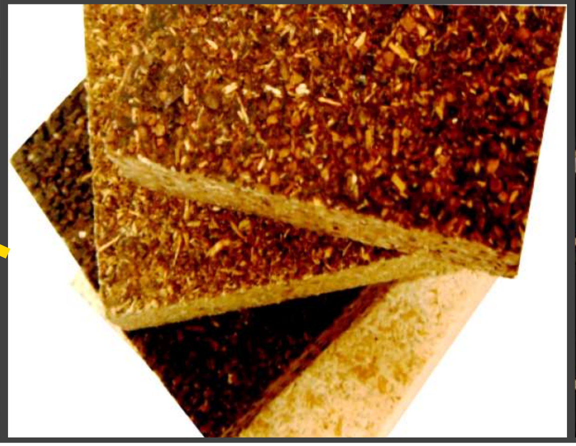
Sustainable Building Products Products

Acoustic Panels

Smart Stone – Glass Panels

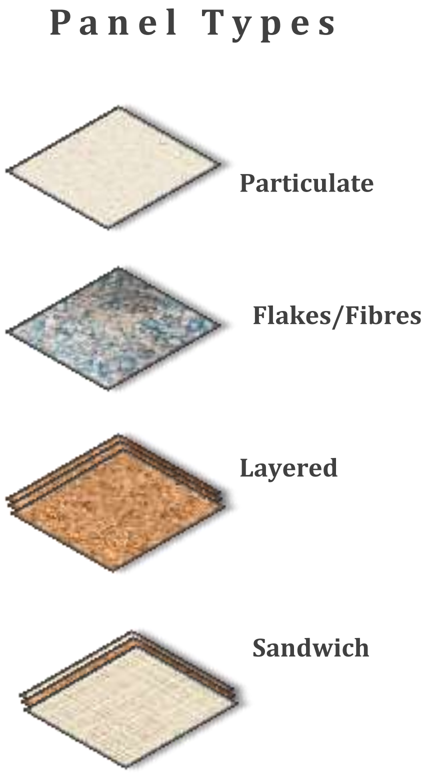


Floor Underlay



Sustainable Particle Board

SMaRT Hybrid Particulate Bio-composites Series



1- Use of Marine wastes as Bio-Fillers in Hybrid Particulate Bio-composites

Insulating Panels

Structural/core panels

Architectural linings

Ceiling Panels

Furniture

Advantage: Structural, Fire-retardant, high-moisture & fungal resistance

Utilization of Waste Textiles & Mattresses in Structural and Acoustic Panels

Acoustic/Insulating Panels

Division panels & Screens

Architectural linings

Ceiling Panels

Prefab. Building Elements

Furniture

Advantage: Acoustic, high-moisture resistance, light-weight

Smart Stone – benchtops, tiles and flooring from waste glass

Benchtops

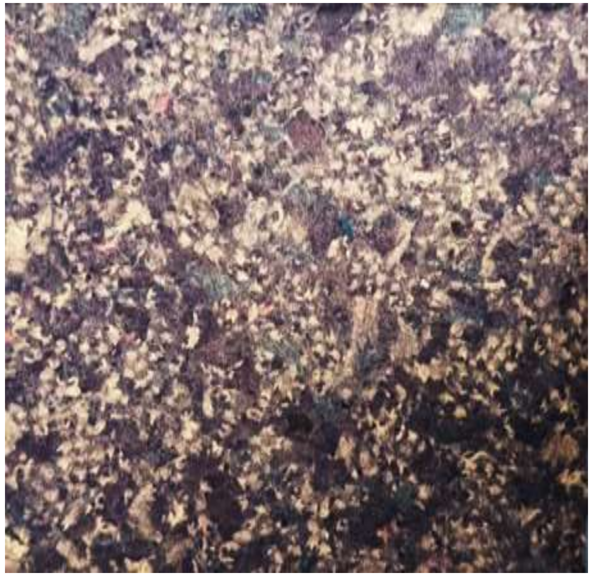
Wall and floor tiling

Kitchen/bathrooms

Advantage: High-strength, moisture resistance

Utilization of Waste Textiles & Mattresses in Structural and Acoustic Composite Panels

Acoustic and Thermal Insulation



Wool blends

Moisture Resistance

Polyester blend

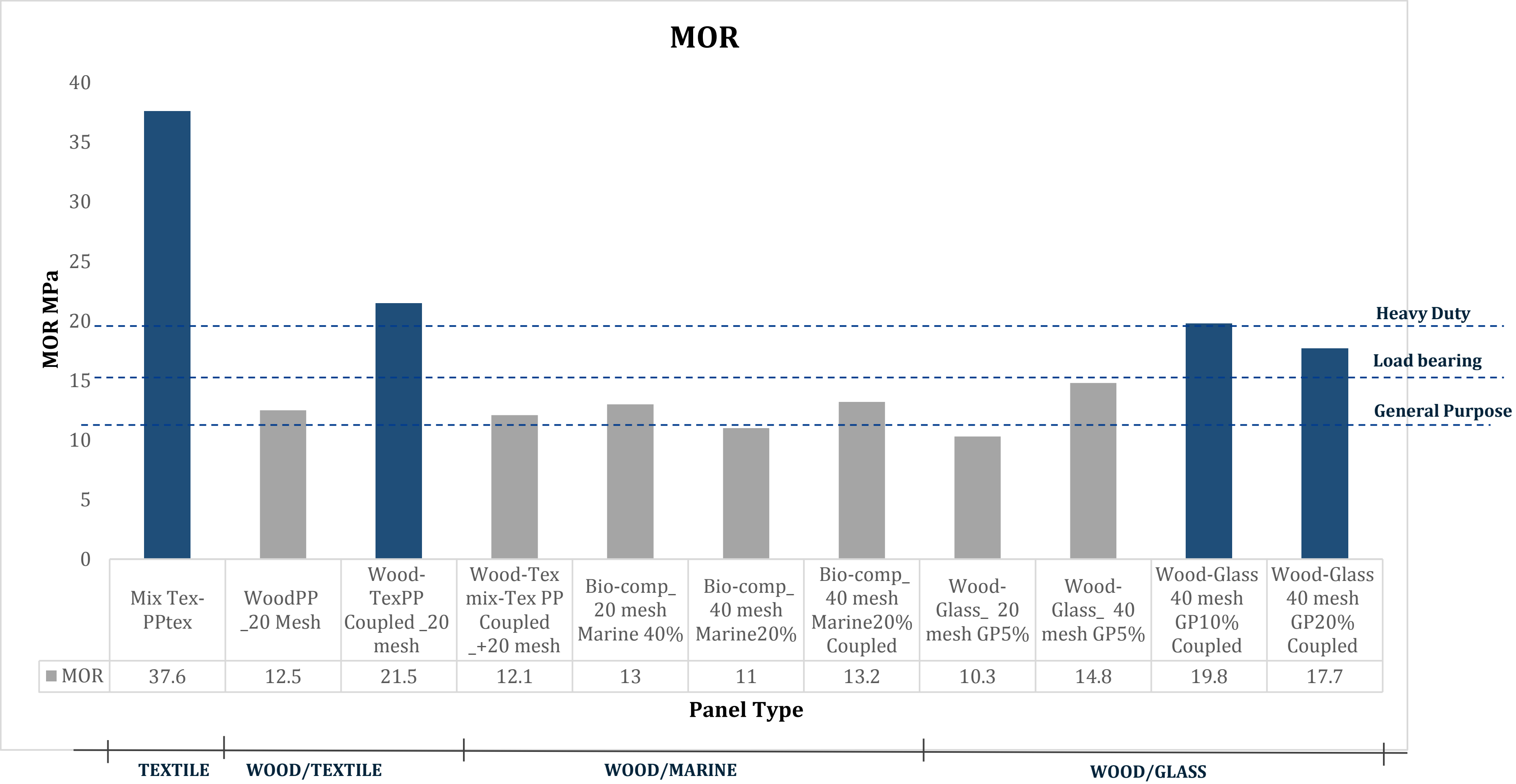
Mechanical Strength_ Moisture Resistance

Polypropylene fleece

Wood flakes

Advantage: Acoustic, high-moisture resistance, light-weight

Comparison of Modulus of Rupture (MOR) of Composite Panels Series



1. Heriyanto, Pahlevani, F., Sahajwalla, V. (2018) Journal of Cleaner Production, 191, 1, 192-206.
2. Echeverria, C., Pahlevani, F., Gaikwad, V., Sahajwalla, V. (2017). Journal of Cleaner Production, 154, 284-294
3. Heriyanto, Pahlevani, F., Sahajwalla, V. (2018). Journal of Cleaner Production, 172, 3019-3027.

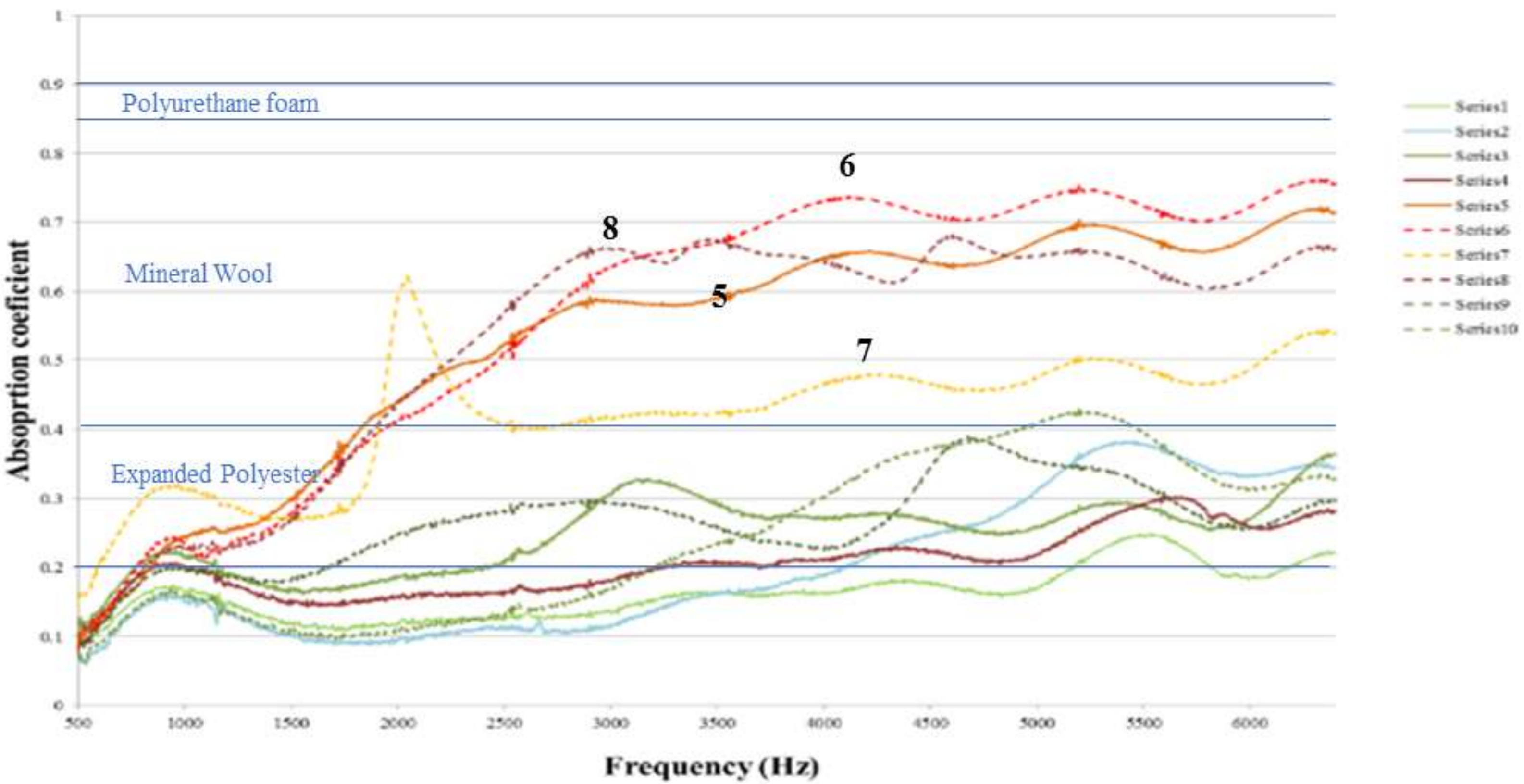
Measurement of Sound Absorption

Panel Sample series

Sample dimensions

ϕ= 29 mm
h ± 4.5 mm

Comparison of the Acoustic Absorption Coefficient Values



Super tough flooring from advertising banners

Flooring

Vibration Insulation

Multipurpose/Customization

Advantage: heavy duty flooring, high-moisture resistance

Cholake, S., Pahlevani, F., Gaikwad, V., Millicer, H., Sahajwalla, V. (2018) Resources, Conservation and Recycling 136:9-21.

SM@RT Paper/Polymer coffee cups & packaging for Insulation panels

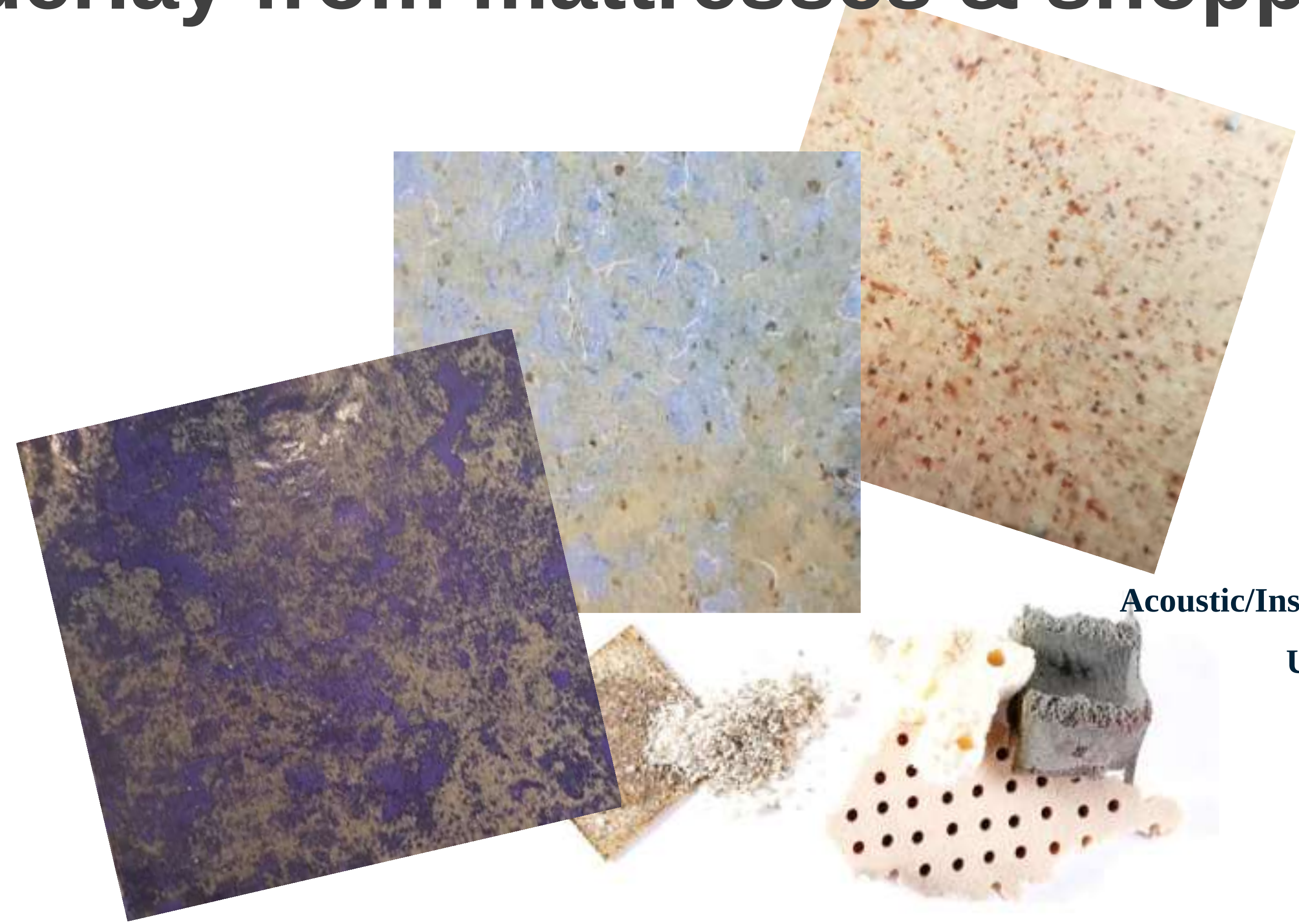
Insulation panels

Division panels

Architectural Linings

Advantage: Light-weight, potential for acoustic and thermal insulation

Floor underlay from mattresses & shopping bags

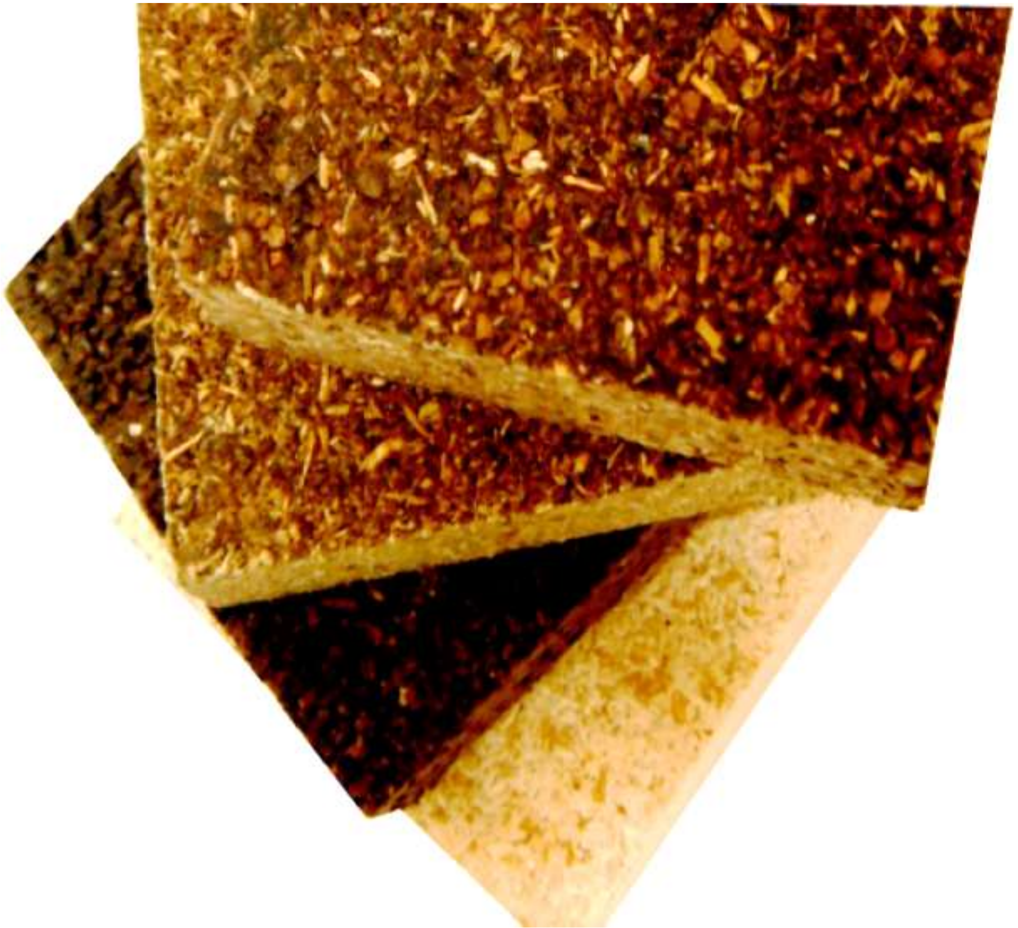


Acoustic/Insulating Panels

Underlay layer

Advantage: Acoustic, high-moisture resistance, light-weight

Utilization of Agrowaste for Sustainable particle boards



Furniture

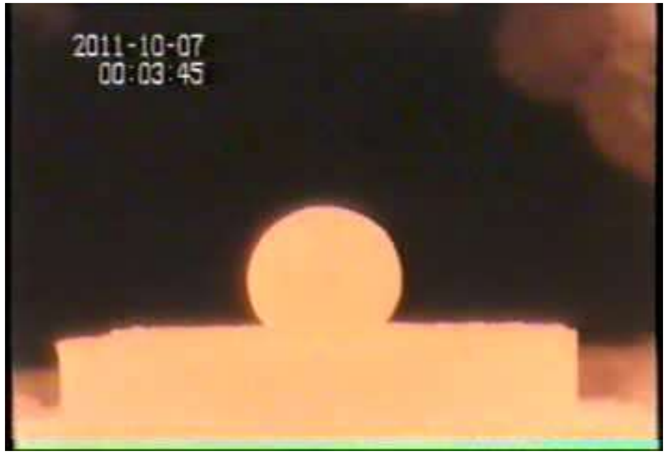
Division panels

Architectural Linings

Advantage: Light-weight, moisture resistance, dimensional stability, non-toxic

Research @ SMaRT Centre on Waste Tyres

Discovered a unique and innovative way to deal with waste like used tyres; by transforming them into a resource by working with Industry Partner - Onesteel



Polymer Injection Technology

So far, 11 million passenger tyres have been used for the production of steel

Sahajwalla, Veena & Zaharia, M & Mansuri, Irshad & Rajarao, R & Dhunna, Renu & Mohd Yunos, Nur Farhana Diyana & Khanna, Rita & Saha-Chaudhury, Narendra & O'Kane, P & Fontana, A & Skidmore, C & Vielhauer, P & O'Connell, D & Knights, D. (2013). 2013 AIST Howe Memorial Lecture: The power of steelmaking - Harnessing high temperature reactions to transform waste into raw material resources. AISTech - Iron and Steel Technology Conference Proceedings. 1. 1-17.

Microfactories: A Global Solution

- UNSW's microfactory technology promises to revolutionise recycling by producing cost-effective green materials.

- Relatively lower entry costs for establishing recycling microfactories mean benefits can be decentralised, including the generation of jobs and economic returns in disadvantaged regions

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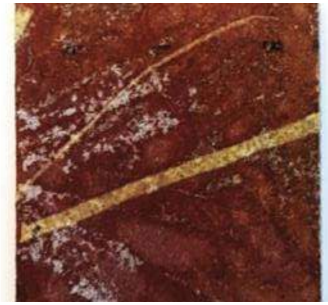
Competitive Advantage & Applications

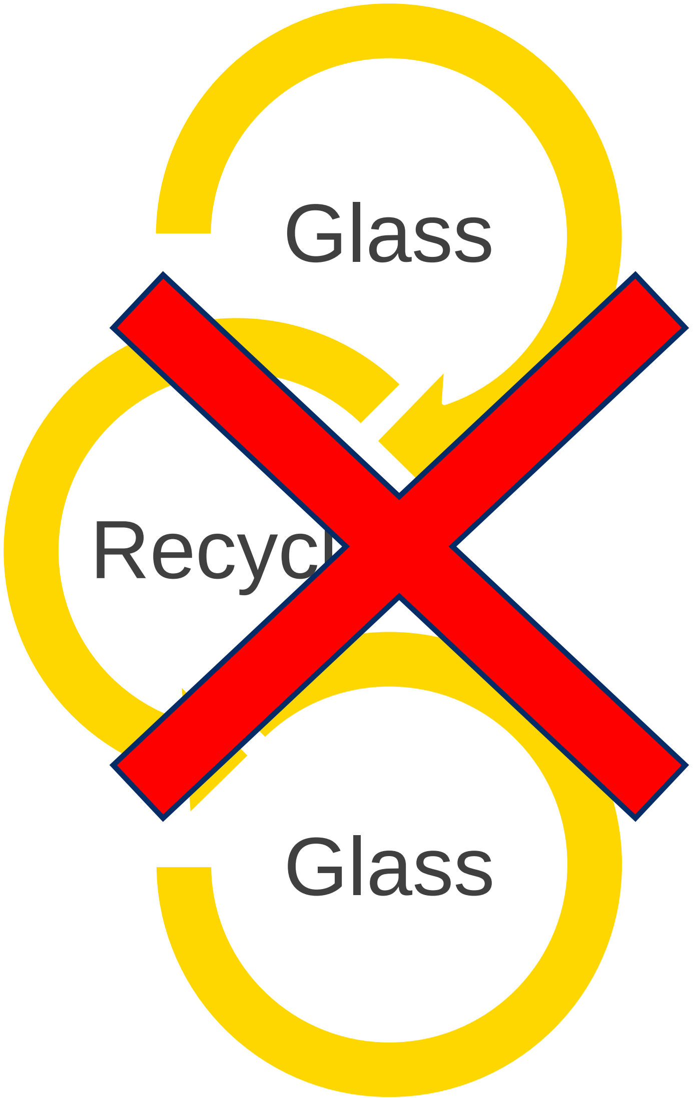
- Low-carbon, Low-cost composite material
- Cost effective alternative to wood based panels
- Lightweight, strong, moisture resistant
- Optimization to costume requirements
- Design for disassembly/recyclability



Need for Innovation

Traditional recycling focuses on reusing materials in their original form – glass into glass, steel into steel.

This model doesn't work with more complex materials



Presentation Outline

1. Rethinking waste – transforming waste into value-added materials

2. Challenges of conventional recycling of waste materials

3. Address challenges and create new opportunities through innovation and partnerships

Need for Innovation

Traditional recycling focuses on reusing materials in their original form – glass into glass, steel into steel.

This model doesn't work with more complex materials

Innovation Journey

- Understanding “Big-Picture” of the business- why innovate?
- New opportunities for business through innovation
- Recognising future challenges

  e.g. materials, environment
- Economic Benefits and value for business
- Human Resources and Pathways

What is innovation?

Innovation can be anything that improves

This ranges from ideas that lead to improved safety, greater efficiency, user-friendly and cost-effective solutions

- Advances in technology
- Competitive-advantage for businesses

Green Materials

We need to consider the introduction of a 4th R, which is REFORM

Reduce, Reuse, Recycle, Reform

Materials processing including use of waste materials as a resource, through innovative thinking, will enhance sustainability and produce value-added green materials

Competitive Advantage & Applications

References:

Ribbed furniture/Wood shells	Acoustic boards/tiles	Tectonic surfaces	Prefab Modular Elements	3D Printing