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

New Technologies and Products

Sustainability of materials processes

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

- **Waste: Polymers, Tyres, Wood, Textiles, Food Packaging**
  - **E-waste Filaments**
  - **Waste: Electronics, Batteries**
    - **PCBs**
    - **E-waste**
  - **High Value Carbon**
    - **Rare Earth Oxides**
  - **Ceramic Materials**
  - **Metal Alloys**
  - **Australian State Governments**

- **Waste: Glass, Industrial, Plastics, Tyres**
  - **Waste: Glass, Industrial, Plastics, Tyres**

- **Products for Steel Making**
  - **Moly-Cop**

- **Consumer and Building Products**
  - **Dresden**
  - **weatherlex**

- **Australia**
  - **Australian State Governments**

- **Thailand**
  - **Australian State Governments**
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 tonnes 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

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

Sources:
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
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
Formation of Sn alloy from PCB

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

Sn-8%Zn 3.1%Pb
Formation of Cu-alloy from PCB

Producing copper alloy via thermal micronizing

Around 90% Copper
Introduced a 4\textsuperscript{th} R, \textit{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
SMaRT Hybrid Particulate Bio-composites Series

Panel Types
- Particulate
- Flakes/Fibres
- Layered
- Sandwich
1- Use of Marine wastes as Bio-Fillers in Hybrid Particulate Bio-composites

Advantage: Structural, Fire-retardant, high-moisture & fungal resistance
Utilization of Waste Textiles & Mattresses in Structural and Acoustic Panels

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

Acoustic/Insulating Panels
Division panels & Screens
Architectural linings
Ceiling Panels
Prefab. Building Elements
Furniture
Smart Stone – benchtops, tiles and flooring from waste glass

Advantage: High-strength, moisture resistance

- Benchtops
- Wall and floor tiling
- Kitchen/bathrooms
Utilization of Waste Textiles & Mattresses in Structural and Acoustic Composite Panels

- Acoustic and Thermal Insulation
- Moisture Resistance
- Mechanical Strength/Moisture Resistance

Wool blends
Polyester blend
Polypropylene fleece
Wood flakes

Advantage: Acoustic, high-moisture resistance, light-weight
Comparison of Modulus of Rupture (MOR) of Composite Panels Series

Measurement of Sound Absorption

Comparison of the Acoustic Absorption Coefficient Values

Polyurethane foam

Mineral Wool

Expanded Polyester

Sample dimensions

$\phi = 29$ mm

$h \pm 4.5$ mm
Super tough flooring from advertising banners

Advantage: heavy duty flooring, high-moisture resistance

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

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

Insulation panels
Division panels
Architectural Linings
Floor underlay from mattresses & shopping bags

Advantage: Acoustic, high-moisture resistance, light-weight
Utilization of Agrowaste for Sustainable particle boards

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

Furniture
Division panels
Architectural Linings
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

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


Polymer Injection Technology
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

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