# A smart vision for a sustainable future

**SMaRT technologies and MICROfactories™ creating sustainable materials and products from waste resources**


## Professor Veena Sahajwalla

ARC Laureate Fellow, Director, Centre for Sustainable Materials Research & Technology
Director, ARC Microrecycling Research Hub
Hub Leader, Sustainable Communities and Waste Hub, National Environmental Science Program


SMaRT@UNSW
Sustainable Materials Research & Technology

Sustainable Communities and Waste
National Environmental Science Program

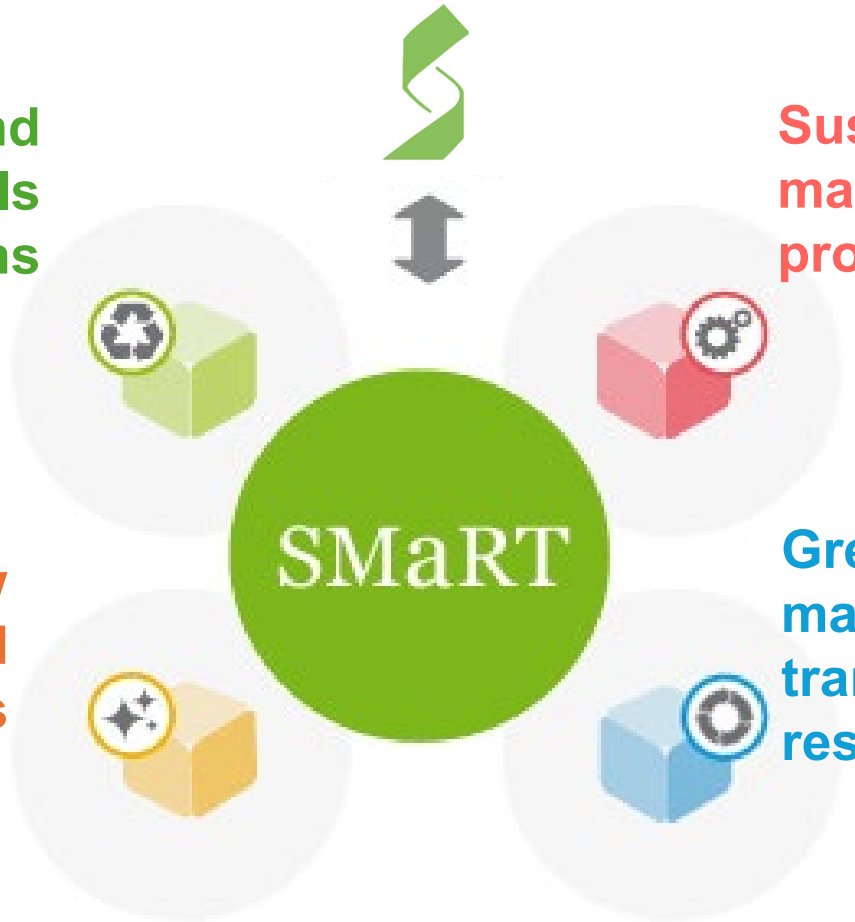
UNSW SYDNEY

# Research focus: Cutting edge sustainable materials & processes

# Outcome: Environmental, social & economic benefits

Recycling and materials transformations

Sustainability of materials processes




New technologies and products

Green manufacturing and translational research

*www.smart.unsw.edu.au*

# The SMaRT Vision

Convert waste materials into high-value materials

Minimise the energy-intensive transportation of waste

Promote and support viable local economies and jobs

An embodiment of distributed manufacturing

# A smart vision for a sustainable future

**This evening we will cover:**

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

2. **Challenges of conventional** recycling of waste materials

3. Addressing challenges and creating new opportunities through **innovation and partnerships**

# E-waste



# Microrecycling transforms waste to value via Thermal Micronising

Recovering copper and other metals from electronic waste are sustainable.

Microrecycling pathways generates different materials from waste, using controlled high temperature transformations.

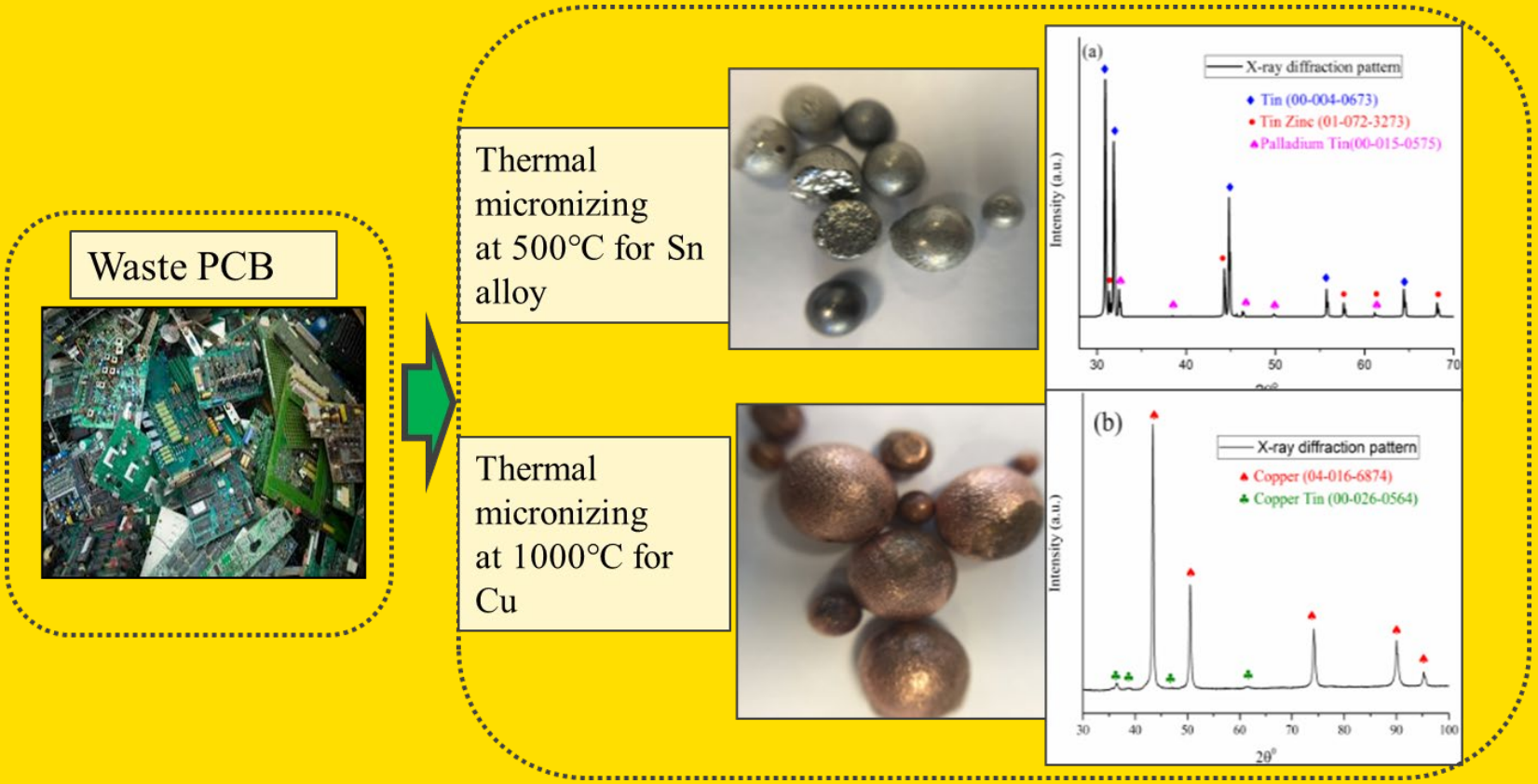
Thermal “micronising” enables the selective synthesis of materials from macro to nano scales at temperatures ranging 400-1550$^{o}$ C.

Patent - A method, apparatus and system for processing a composite waste source. India patent no. 456221, Australia patent no. 2017218454, Chile patent no. 65.222, Japan patent no. 6817314, Europe patent no. 3414507, Germany patent no. 602017030498.0, France patent no. 3414507, United Kingdom patent no. 3414507.

Patent - A process for converting flexible printed circuit boards to useful materials - Australian innovation patent no. 2021106578.

Sahajwalla, V., and R. Hossain. "The science of microrecycling: a review of selective synthesis of materials from electronic waste." *Materials Today Sustainability* 9 (2020): 100040.

# Selectively Creating Value from Waste Printed Circuit Boards by reforming metal alloys

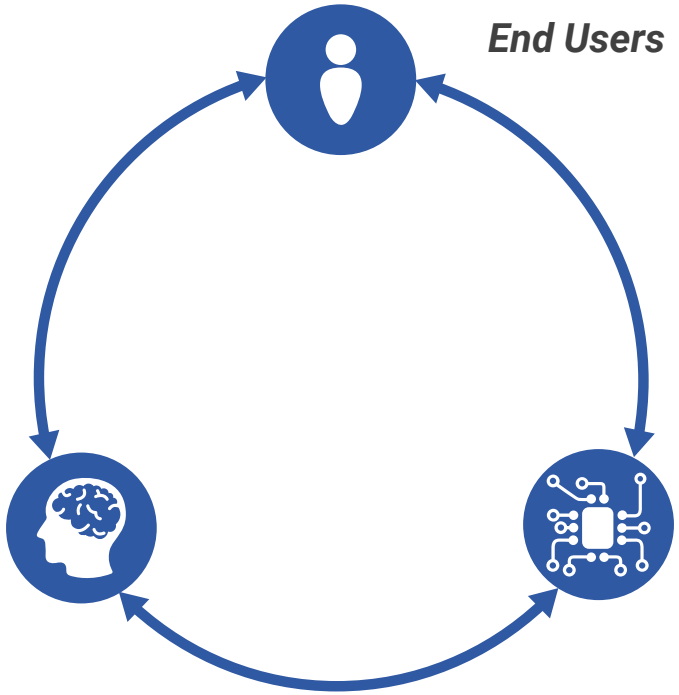



Patent-A method, apparatus and system for processing a composite waste source-India patent no. 456221, Australia patent no. 2017218454, Chile patent no. 65.222, Japan patent no. 6817314, Europe patent no. 3414507, Germany patent no. 602017030498.0, France patent no. 3414507, United Kingdom patent no. 3414507

Hossain, Rumana, Rasoul Khayyam Nekouei, Irshad Mansuri, and Veena Sahajwalla. "Sustainable recovery of Cu and Sn from problematic global waste: exploring value from waste printed circuit boards." *ACS Sustainable Chemistry & Engineering* 7, no. 1 (2018): 1006-1017.


MICRO
factone

# Circular solutions through collaboration and innovation



***End Users***

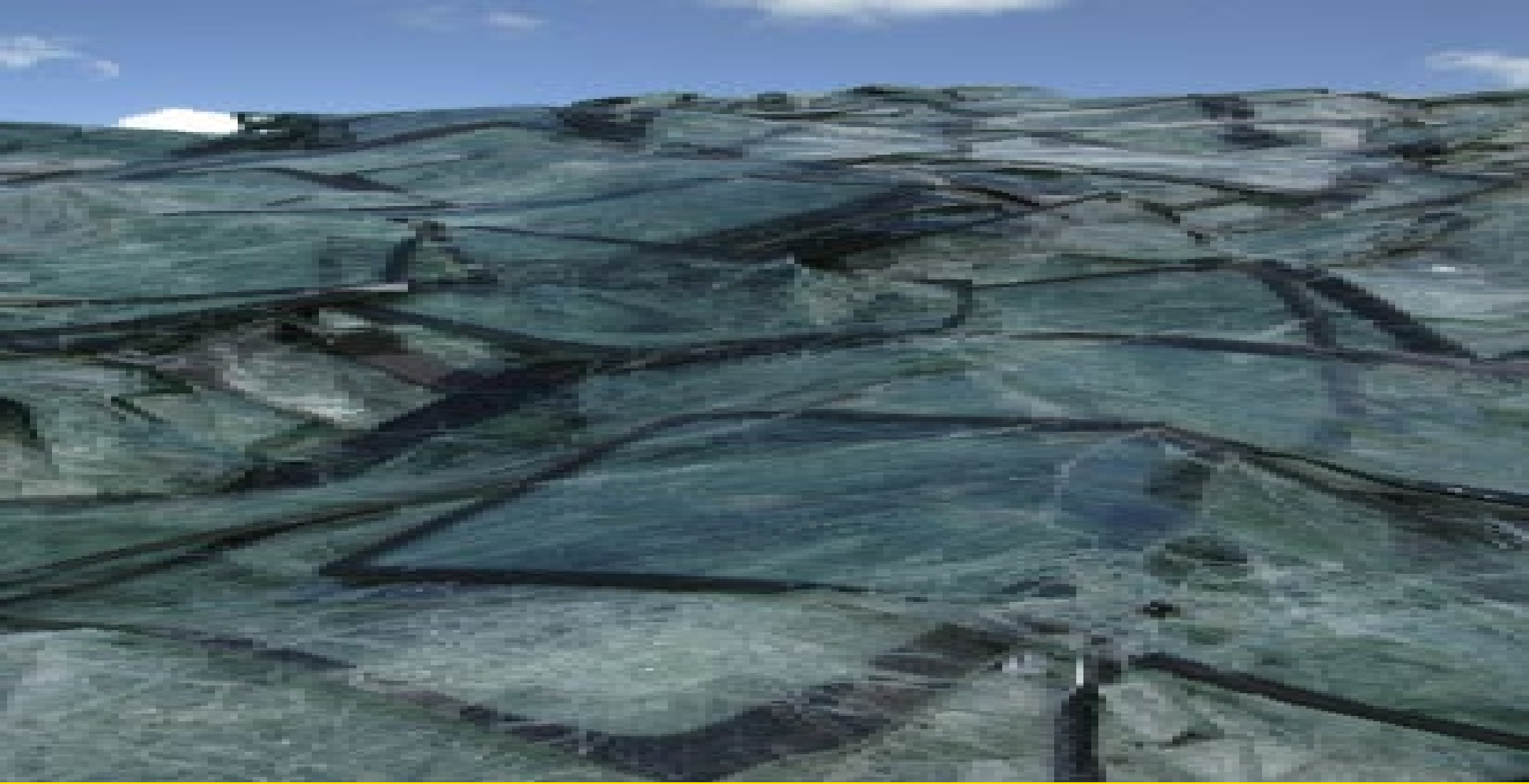
Government
Industry & Community
Infrastructure & Construction
Retailers
Hospitality & Food
Transport
Agriculture

***Producers/Designers***

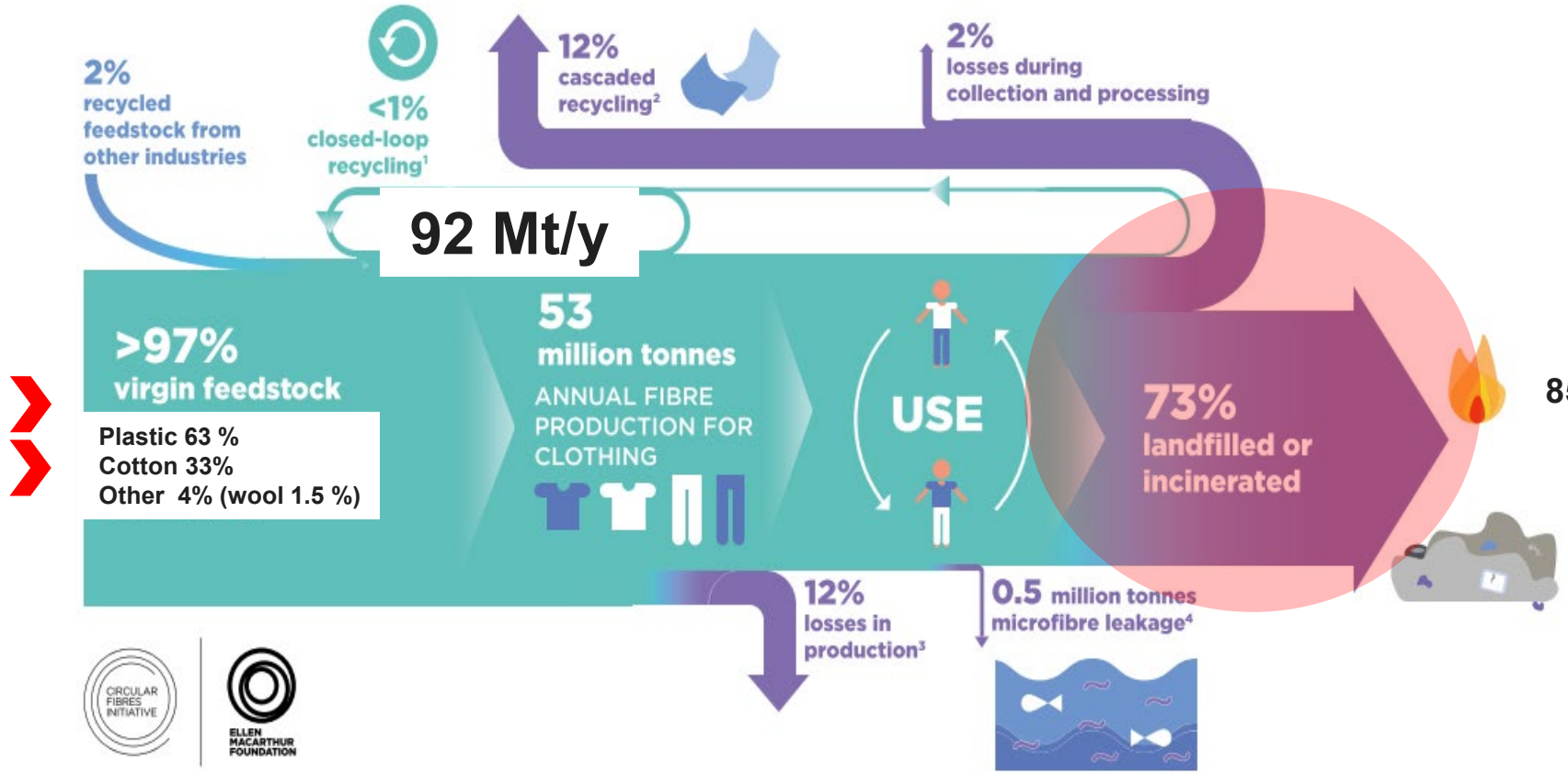
Industry
SMEs
Government
Community
Not-for-profit

***Owners of Waste Materials***

Local Government
MRFs
Industry
Waste Management
Not-for-profit



# Global material flow for apparel waste




85% landfilled or incinerated in Australia

92 million tonnes in 2015 and estimated to increase to 148 million tonnes in 2030 *(Truscott et al., 2017)*

(Ellen Macarthur Foundation, 2017; Truscott et al., 2017)

# SMaRT Centre collaboration with Mirvac

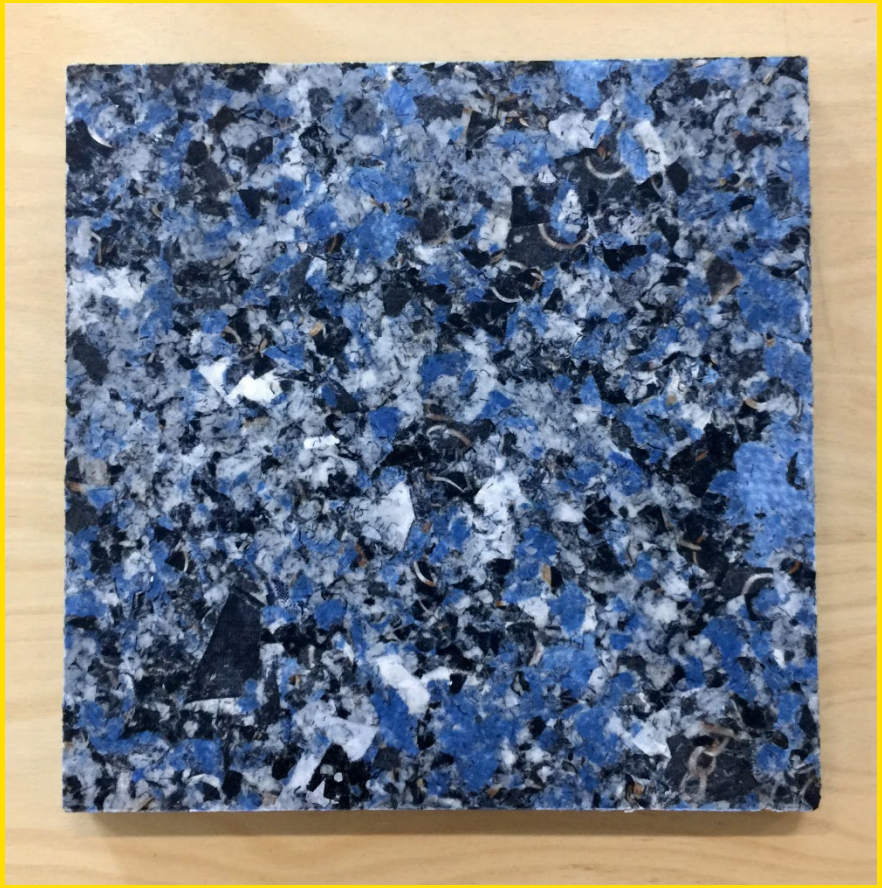






# Glass panel with Textile





Patent-Composite products and the manufacture thereof–Australian Innovation Patent no. 2021104018, Australia National Phase Patent no. 2020251051.

KANDUI TECHNOLOGIES

GREEN ceramics

# Market Ready Technology















UNSW SYDNEY



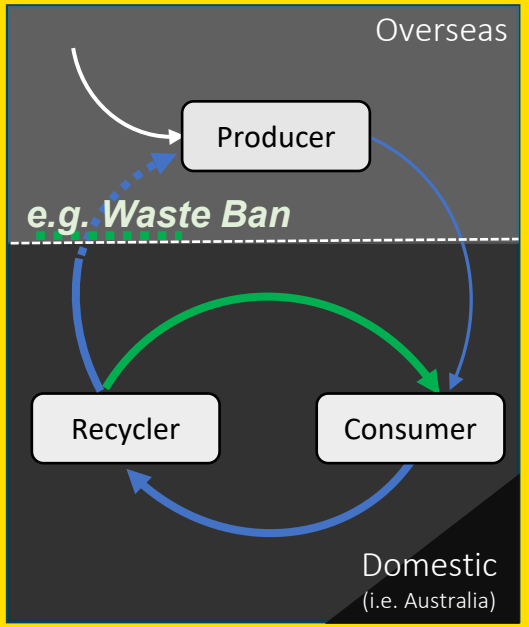
MICROfactorie™ in Cootamundra

In 2021 the SMaRT Centre launched its first commercial, regional MICROfactorie™ in Cootamundra. This MICROfactorie™ has been supported by the Physical Sciences Fund and is in partnership with local businesses. The MICROfactorie™ is located at Mattress Recycle Australia, taking advantage of the waste resources available on site. This partnership was born out of years of research partnership. The relationship with regional businesses has provided a replicable model to scale MICROfactorie™.

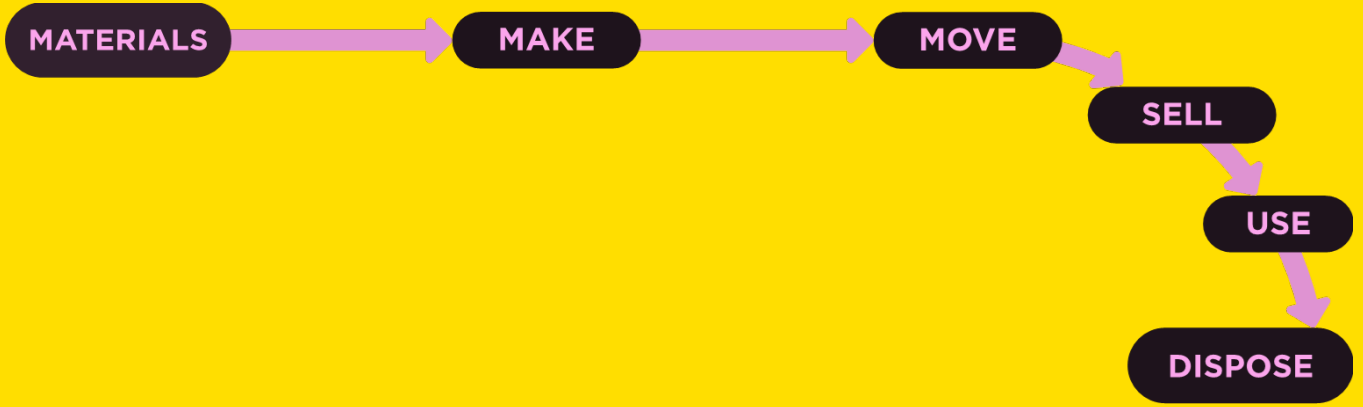
*https://www.smart.unsw.edu.au/news-events/news/abc-australian-story-veena*

# Alignment of Recycling and Manufacturing: Circular economy in action

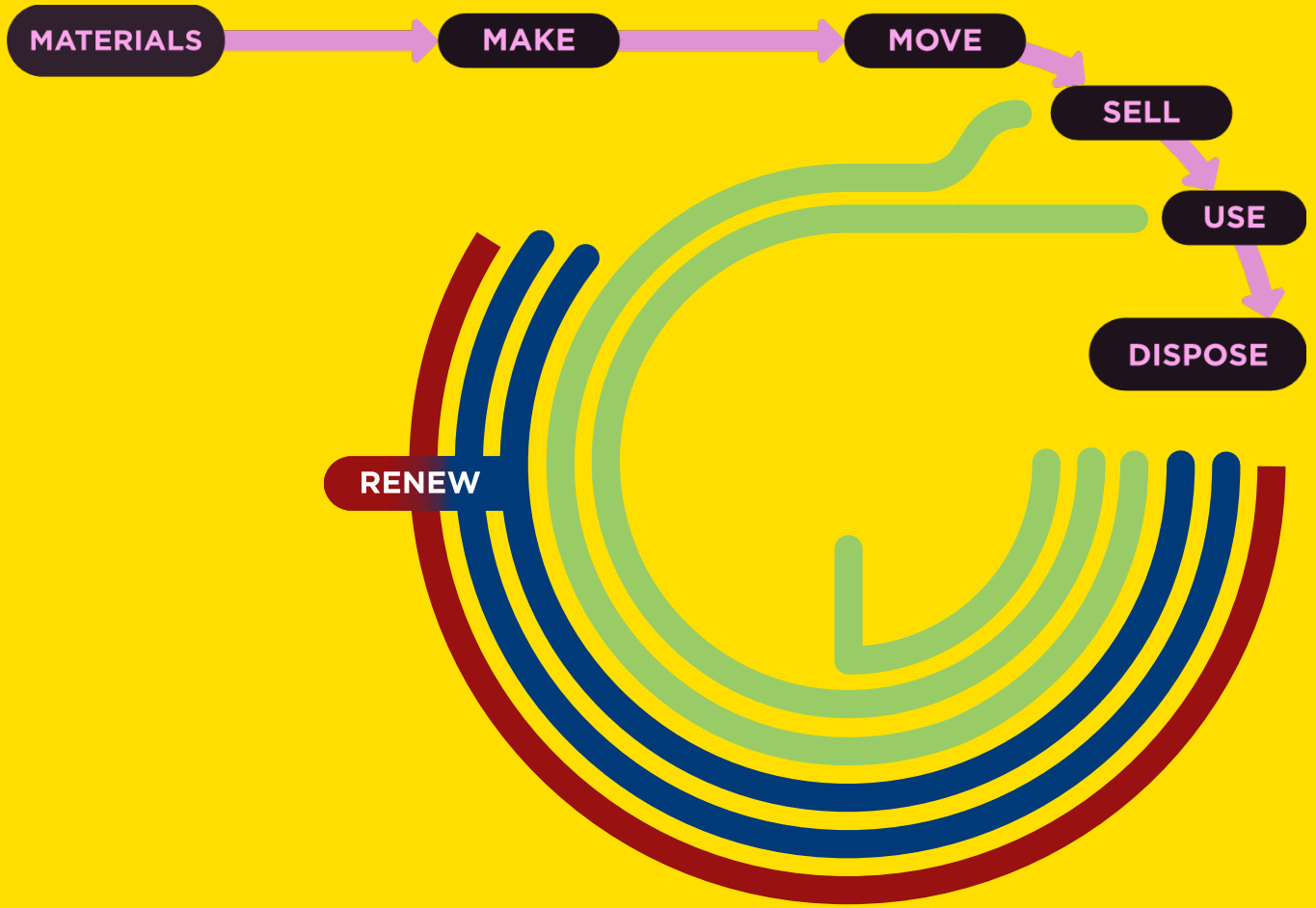
- Holistic solutions for our regions
  - Process the waste regionally instead of overseas
  - Perform value added activities in the community
  - Avoid landfilling and other impacts
- Microrecycling to enable regional recycling
  - Fit for purpose recycling and manufacturing
  - Process plastics, glass and metals from waste
  - Create jobs



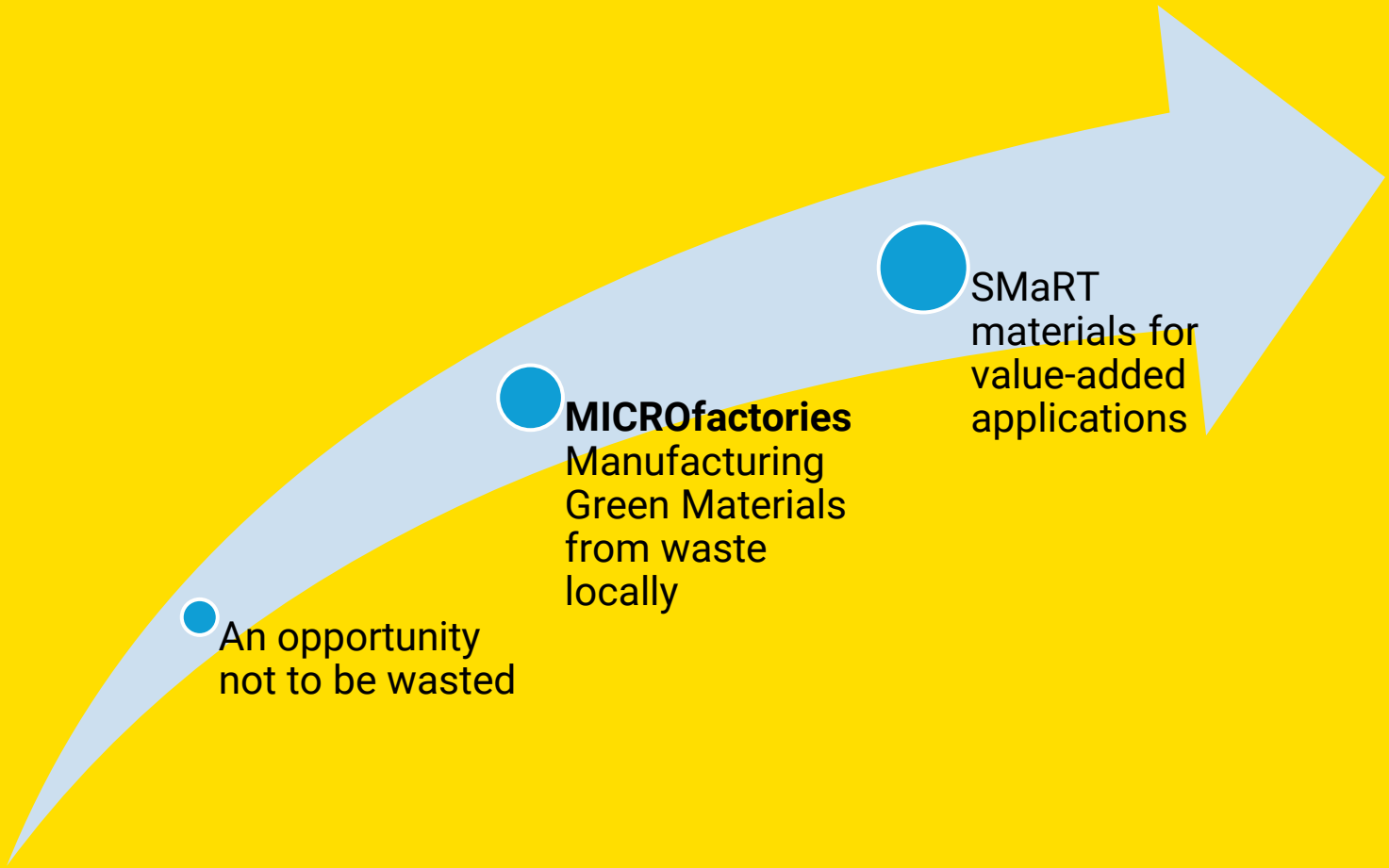
# Supply Chain: Conventional



# Supply Chain: Circular solutions



# Waste to Products through Microfactories



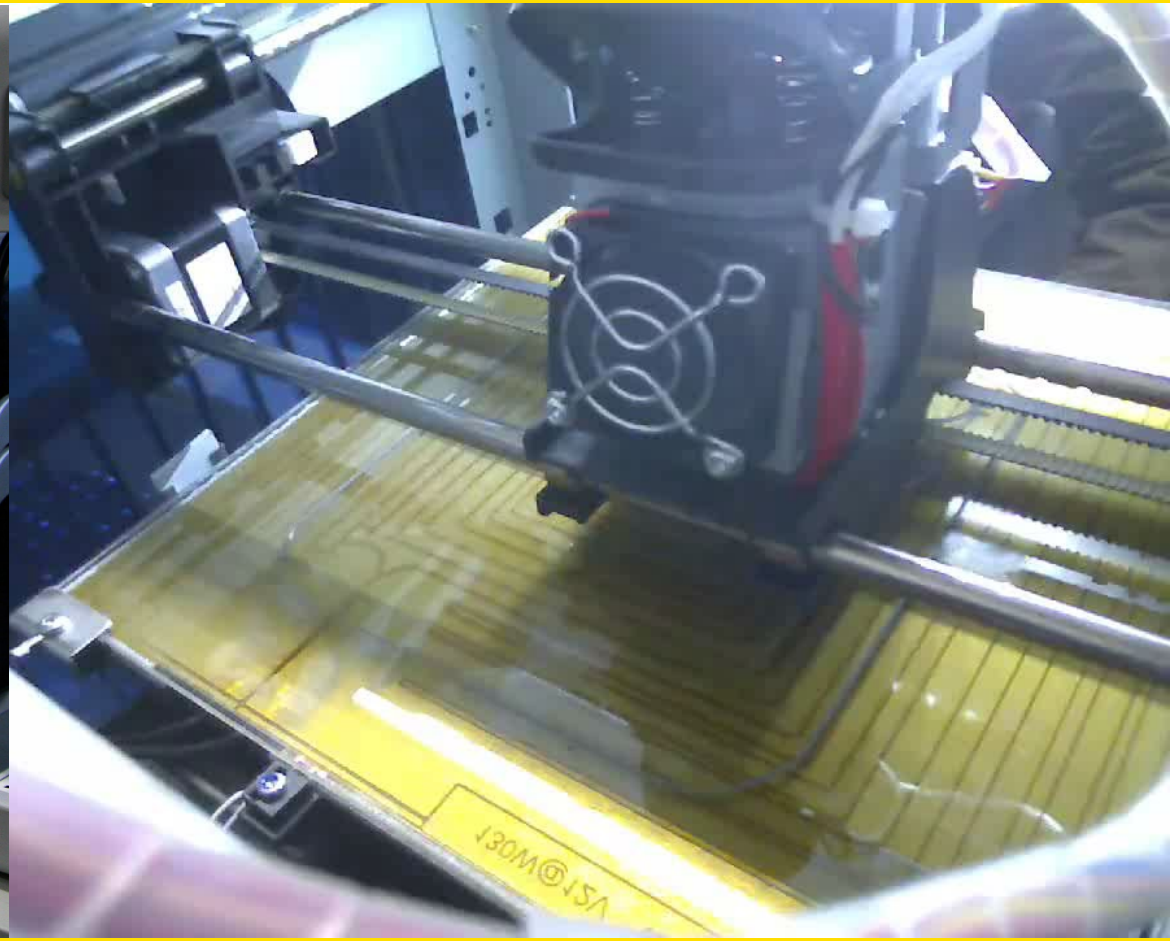

*https://newsroom.unsw.edu.au/news/science-tech/world-first-e-waste-microfactory-launched-unsw*




https://www.youtube.com/watch?v=x738C1R6hrI

# Green manufacturing of plastics



*https://www.smart.unsw.edu.au/research-programs/arc-green-manufacturing-research-hub*




https://www.youtube.com/watch?v=x738C1R6hrI







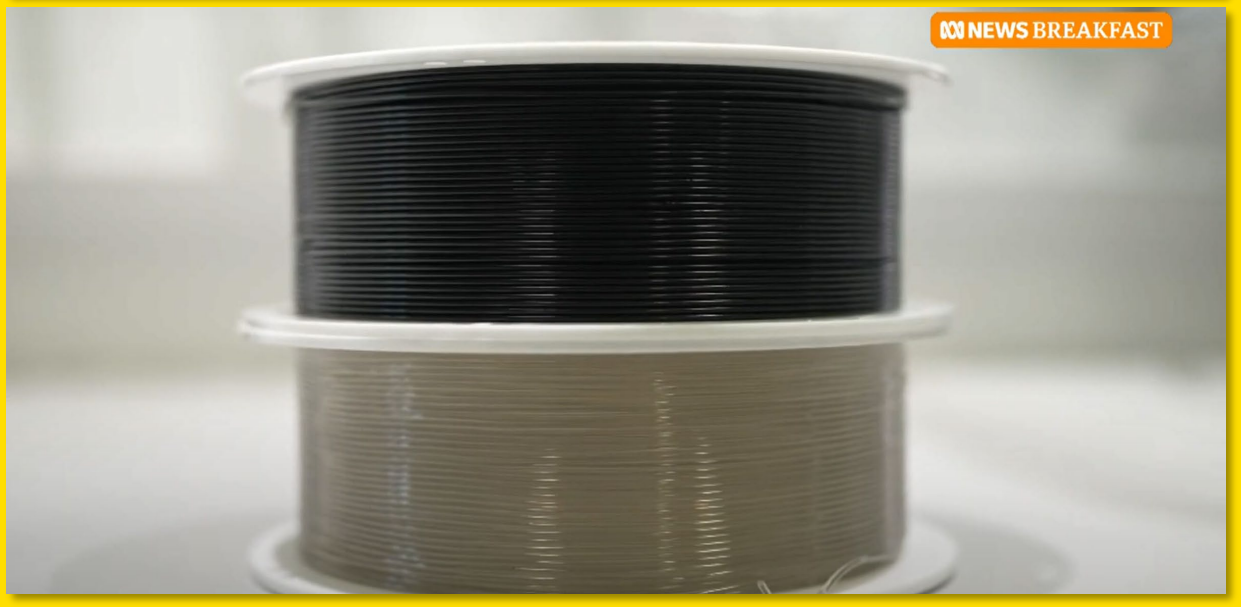



https://www.youtube.com/watch?v=x738C1R6hrI













https://www.youtube.com/watch?v=x738C1R6hrI




https://www.youtube.com/watch?v=x738C1R6hrI

# SMaRT MICROfactories™: A Global Solution

SMaRT MICROfactorie® technology promises to revolutionise recycling by producing cost-effective green materials.

**Value of MICROfactorie**

- Relatively low entry costs for establishing recycling
- Decentralised solution
- Increases safety by minimising transport of waste products
- Local jobs and economic returns

# SMaRT MICROfactories™ Outreach and Engagement



SMaRT innovations at museum exhibit




Manufacturing Academy training



SMaRT at Powerhouse exhibit



Veena on Play School




Study Australia Masterclass Series



Autumn School of Engineering



Science 50:50 educational program




TEDI-London: Summer School

# Vision – Transforming Waste into Value

SMaRT@UNSW is renowned for pioneering the transformation of waste for use as a new generation of ‘green’ materials and products.

Lead a visionary research program that fosters innovation and promotes collaboration with industry and end-users to ensure scientific advances are readily translated into commercially-viable solutions.

Build an unparalleled portfolio of new ‘recycling science’ knowledge and technologies that reform problematic wastes which are not usually subject to conventional recycling, thus ending up in landfill and stockpiles.

Collaborate with many including other researchers, community groups, to transform waste via new science to provide a foundation of scalable and local waste to value solutions that are industry, end user focused to deliver environmental, economic and social outcomes.

[Trademark: SMART@UNSW is registered as a trademark until 25 March 2028 (no.1231277). It covers the following services in class 42: Scientific and technological services and research and design relating thereto; industrial analysis and research services] TradeMark 1231277 | IP Australia | SMaRT@UNSW







Patent- Production of ferro-alloys: Australia patent no. 2005279678; India patent no. 299773; South Korea patent no. 10-1365413; South Africa patent no. 2007/02731; New Zealand patent no. 554303; Mexico patent no. 297415; USA patent no. 8021458; Canada patent no. 2578576; Brazil patent no. PI 0514874-0; Japan patent no. 5594936; Singapore patent no. 155887; Belgium, France, Greece, Luxembourg, Poland, Portugal, Spain, Switzerland, UK patent no. 1799875; Germany patent no. 60 2005 042 014.2; Turkey patent no. TR201401444; Italy patent no. 502014902236951

Patent-Improvements in the production of ferro-alloys: Europe patent no. 2155914 (validated in Belgium, Germany, Spain, France, UK, Italy, Luxembourg and Poland); USA patent no. 8070849; Japan patent no. 5439364; Canada patent no. 2685210; South Africa patent no. 2009/07412; Singapore patent no. 156269; New Zealand patent no. 580591; Mexico patent no. 300856; India patent no. 286414; China patent no. 200880013962.3; Australia patent no. 2008247330; South Korea patent no. 10-1613191

# Innovation – Recycling and reforming of waste as resources in making green steel

New opportunities through recycling science are possible for industry.

Complex wastes could be transformed into material resources.

This could lead to environmental and economic benefits.

[Trademark: SMART@UNSW is registered as a trademark until 25 March 2028 (no.1231277). It covers the following services in class 42: Scientific and technological services and research and design relating thereto; industrial analysis and research services] TradeMark 1231277 | IP Australia | SMaRT@UNSW



# Green Steel - Polymer Injection Technology

Discovering a unique and innovative way to reform waste tyres by transforming them into a resource for EAF steelmaking









**Polymer Injection Technology**

Millions of passenger tyres have been used for the production of steel

**2013 AIST Howe Memorial Award, Pittsburgh, USA.**
**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.
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).

# Green Steel - Polymer Injection Technology

This technology is environmentally sustainable

Plastic or rubber



**Raw material**

Steel making



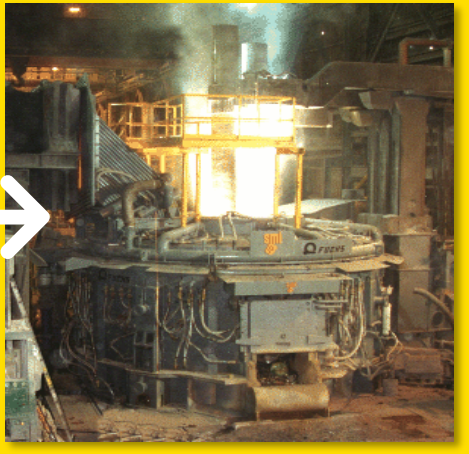
# Green Steel - Polymer Injection Technology

This technology is environmentally sustainable

Plastic or rubber



Steel making





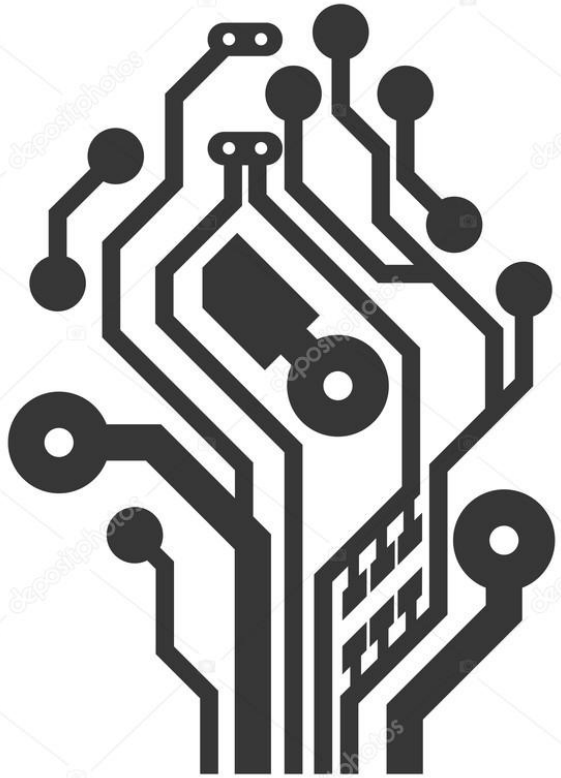

Patent- Production of ferro-alloys: Australia patent no. 2005279678; India patent no. 299773; South Korea patent no. 10-1365413; South Africa patent no. 2007/02731; New Zealand patent no. 554303; Mexico patent no. 297415; USA patent no. 8021458; Canada patent no. 2578576; Brazil patent no. PI 0514874-0; Japan patent no. 5594936; Singapore patent no. 155887; Belgium, France, Greece, Luxembourg, Poland, Portugal, Spain, Switzerland, UK patent no. 1799875; Germany patent no. 60 2005 042 014.2; Turkey patent no. TR201401444; Italy patent no. 502014902236951

Patent-Improvements in the production of ferro-alloys: Europe patent no. 2155914 (validated in Belgium, Germany, Spain, France, UK, Italy, Luxembourg and Poland); USA patent no. 8070849; Japan patent no. 5439364; Canada patent no. 2685210; South Africa patent no. 2009/07412; Singapore patent no. 156269; New Zealand patent no. 580591; Mexico patent no. 300856; India patent no. 286414; China patent no. 200880013962.3; Australia patent no. 2008247330; South Korea patent no. 10-1613191

# Introducing a 4th 'R': *Reform*

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

# A technological approach towards the circular economy for different waste resources in green manufacturing









- Steel is defined as an alloy of iron, carbon and various alloying elements. It is evident that the steel industry needs carbon
- Moreover, the sector is on a pathway of decarbonisation, and the role of hydrogen to achieve the same is gaining worldwide attention
- Certain wastes have both carbon and hydrogen in their molecular structure
- Hence, it is essential to unlock the value through suitable technological solutions (for instance, PIT - Polymer Injection Technology)

# Valuable metals are present in spent batteries

| Valuable metals | Nickel | Cobalt | Manganese | Zinc | Lithium | Copper | Aluminium |
|---|---|---|---|---|---|---|---|
| Amount present in waste batteries ((Kg/ton) | ~200 (Ni-MH)<br>~15 (Li-ion) | ~30 (Ni-MH)<br>~200 (Li-ion) | ~100 (Zn-C)<br>~200 (Alkaline) | ~200 (Zn-C)<br>~120 (Alkaline) | ~30 (Li-ion) | ~160 (Li-ion) | ~50 (Li-ion) |
| *USD/ton | ~23,701 | ~71,000 | ~2600-8000¥ | ~3,672 | ~382500# | ~10,040 | ~3,137 |

*Price of the metals/metric ton (14th February 2022) ; # Li2CO3; ¥ Mn alloy



*www.reuters.com/article/us-southkorea-mining/urban-mining-in-south-korea-pulls-rare-battery-materials-from-recycled-tech-idUSKBN1HJ14T, https://tradingeconomics.com/*

# Microfactories: Our Global Solution

- UNSW's microfactorie technology promises to revolutionise recycling by producing cost-effective green materials
- With relatively lower entry costs for establishing waste, microfactories mean benefits can be decentralised, including the generation of jobs and economic returns
- We can create new innovations to tackling waste, with commercial and end-user benefits using SMaRT's Microrecycling Science and Microfactories
- The SMaRT Centre will develop novel research for sustainable materials and manufacturing processes to create engineered high-quality products from waste resources
- We will build partnerships between industry, local governments, community groups, and research institutes
- We can laterally integrate new material supply networks to create jobs, prosperity and new green materials through collaboration and innovation
- The SMaRT Centre will provide ongoing support to drive circular economy strategies with stakeholders

MICROrecycling offers **new opportunities** for a world looking for waste transformation pathways that **deliver circular economy solutions**

MICROfactories are **enhancing sustainability** and producing **value-added** green materials and products