ReCollect
Efficient Manufacturing of Recyclable Composite Laminates for Electrical Goods
Partners

An independent provider of services relating to composite materials.

They offer a comprehensive range of capabilities that include materials & process development, pilot-scale manufacturing and prototyping.

Coventive Composites will focus on the development of commercially-viable, scalable manufacturing processes for converting raw materials into substrates.

The inventor of Soluboard® – a patented, competitively priced and fully recyclable printed circuit board substrate to rival the industry standard.

Jiva will lead the specification and development of the thermoplastic input materials, as well as the conversion of the substrates into working circuit boards.

A start-up reducing the impact of the fastest growing waste stream in the world using naturally derived products.

The Institute of Circuit Technology (ICT) will support dissemination and stimulate wider UK industry feedback on the developments.
The project focuses on an alternative way of managing end-of-life circuit boards by removing PCBs made from difficult-to-recycle fibreglass-epoxy from the supply chain.

The primary aim of this project is to demonstrate the feasibility of producing Soluboard® in high volumes within the UK and show that Soluboard® can match the performance of CEM-1 and FR-4.

This will be completed using a novel process in development by Coventive Composites which allows the continuous production of sheet material.

The secondary aim of the project is to investigate the ability to chemically protect Soluboard® and allow it to be used in the existing aqueous processes of PCB manufacture.

Start Date: 1st October 2019
Duration: 30 months
Budget: £800,000

Partners: Jiva Materials
Coventive Composites
Institute of Circuit Technology
The UK population is 10 x that of Norway, so the total untreated e-waste of the UK is 727 KT compared to 40 KT in Norway.

### UN Global E-Waste Report 2019

<table>
<thead>
<tr>
<th>E-Waste Generated (per person)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Average</td>
<td>7.3 kg</td>
</tr>
<tr>
<td>EU Average</td>
<td>16.2 kg</td>
</tr>
<tr>
<td>China</td>
<td>20.2 kg</td>
</tr>
<tr>
<td>USA</td>
<td>21.0 kg</td>
</tr>
<tr>
<td>UK</td>
<td>23.9 kg</td>
</tr>
<tr>
<td>Norway</td>
<td>26.0 kg</td>
</tr>
</tbody>
</table>

- Collection Rate: 55.0%
- Collection Rate: 71.0%
Problem

Waste PCBs

Components

Gold  Silver  Palladium

32% of all e-waste consists of small domestic equipment

Source: The Global E-Waste Monitor 2020
Purpose
Exploring how UK could reduce its environmental impact, create economic opportunities + maintain access to critical materials by better managing and minimising e-waste.

Implementing a Circular Economy for Electronic Goods
- How can the UK Government support a move towards a circular economy for electronics?
- Why does recovering materials from electronic waste pose a significant challenge?
- What support is required to facilitate the adoption of recovery technologies?

UK’s Electronic Waste Sector
- Are UK Waste Electrical and Electronic Equipment (WEEE) collection targets achievable?
- What action can the UK Government take to prevent illegal exporting of e-waste?
- How can the UK public awareness of e-waste recycling be improved?

Witnesses
- Gurbaksh Badhan - Chair at National Association of Waste Disposal Officers
- Phil Conran - Chair at Approved Authorised Treatment Facilities Forum
- Louise Grantham - Representative at Waste Electric and Electronic Equipment Scheme Forum
- Eva Gouwens - CEO at Fairphone
- Kevin Consindine - Head of Sustainability at Samsung
- Andrew Mullen - Head of Quality and Sustainability for the UK and Ireland at Beko
- Matthew Manning - Compliance and Recycling Operations Manager at Dixons Carphone
Soluboard®

Dissolves in hot water
Recyclable components
Biodegradable + non-toxic
Comparable to market leaders
A Soluboard® PCB has a 60% lower carbon footprint compared to a standard PCB.

Source: Environmental Resources Management 2020
The carbon footprint of one square metre of Soluboard® is equivalent to 7.1 kg CO2e.

The carbon footprint of one square metre of standard FR-4 PCB is equivalent to 17.7 kgCO2e.

The total net saving is 10.51 kg CO2e – this is a 60% reduction in carbon footprint per square metre.

The plastic saving per square metre of Soluboard® compared to FR-4 is equivalent to 620 g/m².

Source: Environmental Resources Management 2020
Testing & Progress

- Additive + subtractive Processing Guidelines in development.

Highlights:

- Thermal conductivity comparable to FR-4:
  0.256 W/mK @ 22 °C

- Electrical properties comparable to CEM-1 + FR-4:
  CTI PLC 0 @ 600 V

- Flame retardance in-line with UL 94 V0 rating.

- Mechanical properties comparable to CEM-1.
# Soluboard® Testing Data

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Characteristic</th>
<th>Unit</th>
<th>Conditioning</th>
<th>Test Method</th>
<th>FR-4</th>
<th>Spec</th>
<th>CEM-1</th>
<th>Spec</th>
<th>Soluboard®</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Volume Resistivity</td>
<td>Mohm·cm</td>
<td>C-96/35/90 (Time/Temp/RH)</td>
<td>2.5, 17</td>
<td>5E8 - 5E9</td>
<td>&gt; 5E6</td>
<td>4.60E+09</td>
<td>&gt; 1E6</td>
<td>2.35E+06</td>
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<tr>
<td>2</td>
<td>Surface Resistivity</td>
<td>Mohm</td>
<td>C-96/35/90</td>
<td>2.5, 17</td>
<td>5E6 - 5E7</td>
<td>&gt; 1E5</td>
<td>4.20E+08</td>
<td>&gt; 1E4</td>
<td>3.84E+04</td>
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<td>3</td>
<td>Permittivity (1 MHz)</td>
<td>–</td>
<td>C-24/23/50</td>
<td>2.5, 5, 9</td>
<td>4.5 - 4.7</td>
<td>&lt; 5.4</td>
<td>4.4</td>
<td>&lt; 5.4</td>
<td>5.47</td>
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<tr>
<td>4</td>
<td>Permittivity (1 GHz)</td>
<td>–</td>
<td>C-24/23/50</td>
<td>2.5, 5, 9</td>
<td>4.0 - 4.2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4.13</td>
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<tr>
<td>5</td>
<td>Loss Tangent (1 MHz)</td>
<td>–</td>
<td>C-24/23/50</td>
<td>2.5, 5, 9</td>
<td>0.01 - 0.016</td>
<td>&lt; 0.035</td>
<td>0.03</td>
<td>&lt; 0.035</td>
<td>0.064</td>
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<td>6</td>
<td>Loss Tangent (1 GHz)</td>
<td>–</td>
<td>C-24/23/50</td>
<td>2.5, 5, 9</td>
<td>0.01 - 0.016</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.047</td>
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<tr>
<td>7</td>
<td>Arc Resistance</td>
<td>SEC</td>
<td>D-48/50+D-0.5/23 (Time/Temp)</td>
<td>2.5, 1</td>
<td>&gt; 120</td>
<td>&gt; 60</td>
<td>–</td>
<td>–</td>
<td>65</td>
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<tr>
<td>8</td>
<td>Dielectric Breakdown</td>
<td>KV</td>
<td>D-48/50</td>
<td>2.5, 6</td>
<td>&gt; 60</td>
<td>&gt; 40</td>
<td>&gt; 60</td>
<td>&gt; 40</td>
<td>32</td>
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<tr>
<td>9</td>
<td>Moisture Absorption</td>
<td>%</td>
<td>D-48/50</td>
<td>2.6, 2, 1</td>
<td>0.05 - 0.10</td>
<td>&lt; 0.35</td>
<td>&lt; 0.15</td>
<td>&lt; 0.5</td>
<td>96</td>
</tr>
<tr>
<td>10</td>
<td>Flammability</td>
<td>–</td>
<td>D-48/50</td>
<td>UL94</td>
<td>94V0</td>
<td>94V0</td>
<td>94V0</td>
<td>94V0</td>
<td>94V0</td>
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<tr>
<td>11</td>
<td>Peel Strength (1 oz)</td>
<td>lb/in</td>
<td>288°C×10* (Soil Floating)</td>
<td>2.4, 8</td>
<td>8 to 12</td>
<td>&gt; 6</td>
<td>11</td>
<td>&gt; 6</td>
<td>142</td>
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<tr>
<td>12</td>
<td>Thermal Stress</td>
<td>SEC</td>
<td>288°C (Dipping)</td>
<td>2.4, 13, 1</td>
<td>&gt; 200</td>
<td>&gt; 10</td>
<td>&gt; 80</td>
<td>&gt; 40</td>
<td>142</td>
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<tr>
<td>13</td>
<td>Flexural Strength (LW)</td>
<td>N/mm²</td>
<td>A</td>
<td>2.4, 4</td>
<td>480 - 550</td>
<td>&gt; 415</td>
<td>300 - 400</td>
<td>&gt; 242</td>
<td>142</td>
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<tr>
<td>14</td>
<td>Flexural Strength (CW)</td>
<td>N/mm²</td>
<td>A</td>
<td>2.4, 4</td>
<td>415 - 480</td>
<td>&gt; 345</td>
<td>200 - 300</td>
<td>&gt; 172</td>
<td>96</td>
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<tr>
<td>15</td>
<td>Dimensional Stability (X-Y axis)</td>
<td>%</td>
<td>E-0.5/170 (Time/Temp)</td>
<td>2.4, 3, 9</td>
<td>0.005 - 0.030</td>
<td>&lt; 0.05</td>
<td>&lt; 0.065</td>
<td>&lt; 0.11 (Max)</td>
<td>125</td>
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<tr>
<td>16</td>
<td>Glass Transition Temperature</td>
<td>C</td>
<td>DSC</td>
<td>2.4, 25</td>
<td>140 +/ - 5</td>
<td>N/A</td>
<td>100</td>
<td>N/A</td>
<td>125</td>
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<tr>
<td>17</td>
<td>Z-axis (Before Tg)</td>
<td>ppm/C</td>
<td>TMA</td>
<td>2.4, 24</td>
<td>50 - 70</td>
<td>N/A</td>
<td>–</td>
<td>–</td>
<td>125</td>
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<tr>
<td>18</td>
<td>Z-axis (After Tg)</td>
<td>ppm/C</td>
<td>TMA</td>
<td>2.4, 24</td>
<td>250 - 350</td>
<td>N/A</td>
<td>–</td>
<td>–</td>
<td>125</td>
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<tr>
<td>19</td>
<td>Punchability</td>
<td>kg/cm²</td>
<td>ASTM D-752 (Shear Strength)</td>
<td>–</td>
<td>–</td>
<td>900</td>
<td>N/A</td>
<td>227</td>
<td></td>
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<tr>
<td>20</td>
<td>Comparative Tracking Index</td>
<td>V</td>
<td>C-96/20, 65</td>
<td>600</td>
<td>PLC 0 (&gt; 600)</td>
<td>&gt; 600</td>
<td>N/A</td>
<td>PLC 0 (500V)</td>
<td>227</td>
</tr>
</tbody>
</table>

C= Humidity Conditioning; D= Immersion Conditioning in Distilled Water; E= Temperature Conditioning
Market

- Annual demand for FR-4 glass-epoxy circuit boards is 18.8 billion m², growing at 4.5% per annum.
- The FR-4 market can be segmented into 2.8 billion m² of single/double-sided boards – Jiva’s target market.
- 485 million household appliances sold globally in 2017. This is 14.6 million m² of laminate with a value of £220M.
- Jiva predicts a realistic addressable market of 17 million m² (£250 million). This estimate is based on:
  - The overall market opportunity for single/double-sided FR-4 boards;
  - The obligations, willingness and capability to manage white goods at end-of-life;
  - Territorial accessibility considerations;
  - Market inertia in transitioning from an incumbent technology.
- Jiva is targeting a 5% share by 2027, translating to 0.85 million m² of Soluboard worth £13 million.
Finalist in the Postcode Lotteries Green Challenge.

One of the largest annual competitions for sustainable entrepreneurship.

Results to be aired on Dutch TV in February 2021.

- First Prize: €500k
- Second Prize: €200k
- Runners Up: €100k
THANK YOU

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- **WP1 - Commercialisation**
  Focusing on the specific market requirements of white goods and the coordination of dissemination and exploitation activities.

- **WP2 - Raw Materials**
  Optimisation of the natural fibre reinforcements to meet processing and performance requirements for Soluboard manufacture.

- **WP3 - Substrate Manufacture**
  Evaluation of thermoplastic sheet extrusion and fabric impregnation process and testing of the resulting substrates against FR-4.

- **WP4 - PCB Production**
  Assessment of circuitry application to the substrate produced using the conventional copper etching process and silver printing.

- **WP5 - Case Studies**
  Design, manufacturing and evaluation of fully functioning populated PCBs as specified by the end customer.

- **WP6 - Project Management**
  Overall coordination, administration, monitoring and planning of the project.
Impacts

Environmental & Social

- Analysis has shown that large household appliances i.e. white goods are the largest contributor to UK e-waste at 320 KT per year.

- The electronic components that PCBs are populated with often contain toxins, such as lead, cadmium and mercury.

- The Global E-Waste Monitor 2019 report states that of the 53.6 Mt of e-waste generated globally, only 9.3 Mt was documented as collected and recycled - less than 20%.

- Jiva will push for the safe recovery of e-waste and address directly the environmental issues it can cause.

Economic

- The current cost of landfill is £91.35 per tonne. This is a significant non-productive cost to the UK economy when dealing with e-waste.

- The UK is now far behind Europe for natural fibre production, with minimal flax grown and only 800 hectares of hemp grown compared to 33,000 hectares in Europe.

- A demand for natural fibre reinforcements for use in PCBs could help invigorate the UK rural economy.