Aluminium Research for Road Transport Applications

Geoff Scamans
Innoval Technology and Brunel University
### EPSRC funding in the area of light metals

This chart includes funding in the area of light metals, either current or announced, in April 2013. Grants are grouped into categories. The named investigators and institutions are those for the Principal Investigators on the grant and the figures represent EPSRC’s contribution (80% FEC). Some grants will have a complete light metals focus, others (in particular large grants) will have other metals and materials as aspects of their research.

<table>
<thead>
<tr>
<th>Year</th>
<th>Grant Details</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>DTC in Advanced Metallic Systems - Sheffield/Manchester</td>
<td>£6,364,458</td>
</tr>
<tr>
<td>2006</td>
<td>DTP in Structurally Metallic Systems for Gas Turbine Applications - Cambridge/Swansea/Birmingham</td>
<td>£6,819,398</td>
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<tr>
<td>2007</td>
<td>A Centre for Doctoral Training on the Theory and Simulation of Materials – Imperial</td>
<td>£6,414,829</td>
</tr>
<tr>
<td>2008</td>
<td>Industrial Doctorate Centre: Micro- and NanoMaterials and Technologies – Surrey</td>
<td>£6,168,139</td>
</tr>
<tr>
<td>2009</td>
<td>Industrial Doctorate Centre in Advanced Forming and Manufacture– Strathclyde</td>
<td>£1,231,298</td>
</tr>
<tr>
<td>2010</td>
<td>Step change materials efficiency for steel and aluminium -Allwood – Cambridge</td>
<td>£1,565,446</td>
</tr>
<tr>
<td>2011</td>
<td>Reducing Emissions by Exploiting Field-Induced Martensitic Transformations Dye – Imperial</td>
<td>£1,151,930</td>
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<tr>
<td>2012</td>
<td>Light Alloys Towards Environmentally Sustainable Transport LATEST2 – Thompson - Manchester</td>
<td>£5,762,121</td>
</tr>
<tr>
<td>2013</td>
<td>Centre for Innovative Manufacturing: Liquid Metal Engineering Brunel/Oxford/Birmingham</td>
<td>£5,119,391</td>
</tr>
<tr>
<td>2014</td>
<td>Rolls-Royce Strategic Partnership Structural Metallic Systems for Gas Turbines– Birmingham/Cambridge/Swansea/Sheffield</td>
<td>£7,521,798</td>
</tr>
<tr>
<td>2015</td>
<td>Hybrid through process modelling IMMPEUS – Sheffield</td>
<td>£4,517,347</td>
</tr>
<tr>
<td>2016</td>
<td>SAMULET4: UFG Ti-6Al-4V for DB/SPF and Hot-Die Forging of Titanium – Rosochowski, Ewing, Ion, Quin Strathclyde</td>
<td>£2,342,379</td>
</tr>
<tr>
<td>2017</td>
<td>Towards Affordable, Closed-Loop Recyclable Future Low Carbon Vehicle Structures - TARF-LCV Brunel/Manchester/Imperial/Nottingham/Strathclyde/Exeter/Brookes/Coventry</td>
<td>£4,221,482</td>
</tr>
<tr>
<td>2018</td>
<td>UK Indemand: a National Research Centre for reducing Industrial Energy and Material use Allwood – Cambridge/Bath/Leeds/Trent</td>
<td>£6,173,069</td>
</tr>
<tr>
<td>2019</td>
<td>UK Indemand: a National Research Centre for reducing Industrial Energy and Material use Allwood – Cambridge/Bath/Leeds/Trent</td>
<td>£6,173,069</td>
</tr>
<tr>
<td>2020</td>
<td>Centre for Innovative Manufacturing in Laser-based Production Heriot-Watt/Cambridge/Cranfield/Liverpool/Manchester</td>
<td>£5,571,751</td>
</tr>
</tbody>
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EPSRC funding for aluminium research

This chart includes funding in the area of light metals, either current or announced, in April 2013. Grants are grouped into categories. The named investigators and institutions are those for the Principal Investigators on the grant and the figures represent EPSRC’s contribution (80% FEC). Some grants will have a complete light metals focus, others (in particular large grants) will have other metals and materials as aspects of their research.

Key:
- Fellowships
- Programme Grants
- Centre for Innovative Manufacturing
- Responsive Funding

Steel & Al

Light Metals

Step change materials efficiency for steel and aluminium
- Allwood – Cambridge — £1,565,446

Light Alloys Towards Environmentally Sustainable Transport LATEST2
- Thompson - Manchester – £5,762,121

Centre for Innovative Manufacturing: Liquid Metal Engineering
Brunel/Oxford/Birmingham — £5,119,391

Hybrid through process modelling
IMMPETUS – Sheffield – £4,517,374

Towards Affordable, Closed-Loop Recyclable Future
Low Carbon Vehicle Structures - TARF-LCV
Brunel/Manchester/Imperial/Nottingham/Strathclyde/Exeter/Brookes/Coventry £4,221,482

Grain refiner for high performance light metal castings
Babu Nandela – Brunel £121,144

Energy saving in the Foundry Industry
Jolly – Cranfield £116,344

Cavitation Melt Processing: (UltraMelt)
Eskin – Brunel £340,919

Precision guided flexible forming
Allwood – Cambridge/Bath/Leeds/Trent £1,707,194

Energy saving in the Foundry Industry
Jolly – Cranfield £116,344

UK Indemand: a National Research Centre for reducing Industrial Energy and Material use
Allwood – Cambridge/Bath/Leeds/Trent £6,173,069

Centre for Innovative Manufacturing in Laser-based Production
Heriot-Watt/Cambridge/Cranfield/Liverpool/Manchester— £5,571,751
Understanding Heterogeneous Nucleation and Grain Refinement

Z. Fan

BCAST, Brunel University, Uxbridge, UK
Nucleation - TiB$_2$ (in 51GR)

OR: (0001)[11-20]$_{\text{TiB}_2}$ // (111)[0-11]$_{\text{Al}}$
Nucleation - TiB$_2$ (in 51GR)

EELS Mapping Using SuperSTEM

Local Z-contrast

Ti K-edge mapping (green)

Z-contrast and Ti-mapping
Nucleation mechanism

OR: (0001)[11-20]TiB$_2$ // (112)[-201]Al$_3$Ti(2D) // (111)[0-11]Al

TiB$_2$/Al: f = -4.2%; Al$_3$Ti(2D)/Al: f $\rightarrow$ 0.09%;
Liquid metal engineering

Twin screw mechanism

Rotor-stator mechanism
MC-DC casting process
MC-DC 6063 billet

20mm
Solidification mechanism
Summary

- A new technology, MC-DC casting process
- Fine and uniform microstructure, uniform chemistry and fewer defects
- Unique solidification mechanism: sedimentation of rosettes
- Wider alloy range for DC casting
Towards Affordable, Closed-Loop Recyclable Future Low Carbon Vehicle Structures: Metallic Materials Group Objectives

Geoff Scamans

BCAST, Brunel University
Research Vision and Ambition

2011

- Primary input materials
- Vehicle manufacturing
- Vehicle use
- ELVs

2030

- Limited input of primary materials
- Low-carbon input lightweight materials
- Low-carbon manufacturing technologies
- Mass-optimised design for low-carbon usage
- Reuse & remanufacture
- ELVs (end of life vehicles)

- Closed-loop recycling
- Dismantling of ELVs

- Significantly reduced CO₂
- Minimal waste for land filling
- CO₂ emission
- Recovered metals (down graded)
- Waste for land filling

Limited input of primary materials

Low-carbon input lightweight materials

Low-carbon manufacturing technologies

Mass-optimised design for low-carbon usage

Reuse & remanufacture

Dismantling of ELVs

ELVs (end of life vehicles)
Project Objectives

- To develop closed-loop recyclable Al-alloys and self-corrosion-resistant Mg-alloys
- To develop advanced PMCs using recyclable rGFs, rCFs and recoverable rNFs
- To develop novel technologies for liquid metal treatment to enable closed-loop recycling
- To develop advanced technologies for LC manufacturing and effective disassembly of ELVs
- To develop mass-optimised vehicle design principles
- To develop specific LCA methodology for future LCV development
Recyclable Aluminium BIW

- Magnesium content is not an issue
- AlSi casting alloys result in a high silicon level in the remelted BIW alloy
- AlMg casting alloys are a promising alternative
- Tolerance of iron is important for casting, sheet and extrusion alloys
- Recycled alloy should be the closure panel AA6xxx alloy
Al-Mg-Si DIE-CAST ALUMINIUM ALLOY

Suraj Pawar, Xiaorong Zhou, Joseph Robson and Prof. George Thompson

Corrosion and Protection Centre, School of Materials, The University of Manchester, UK.

In collaboration with

Prof. Geoff Scamans and Prof. Zhongyun Fan

BCAST, Brunel University, London, UK

TARF-LCV PROGRAM, EPSRC, UK.

✓ Part-I: Microstructure investigation
✓ Part-II: Influence of micro-constituents on corrosion behaviour
Branched/connected morphology of Mg₂Si IM
SKPFM analysis: SKPFM analysis showing the VPD of individual IM phases

α-Al-matrix (dotted line)

Possibilities of the micro-galvanic coupling
- Fe-Mn IM – Mg₂Si
- Fe-Mn IM – α-Al

Surface topography (2D)  Surface potential (3D)
## TSB funding in the area of light metals (aluminium and magnesium)

This chart includes collaborative R&D projects with a significant light metal content that have been funded from competitions from 2004 to 2013. The figures represent the total value of the project. TSB typically provides 50% of the funding support inline with state aid rules.

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Description</th>
<th>Funding</th>
<th>Collaborators</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Development of the rheo-diecasting process for lightweight automotive components (RDC)</td>
<td>£1,673,893</td>
<td>Innoval, Brunel University, Ford Jaguar, JMV Castings, Meridian, NAMTEC</td>
</tr>
<tr>
<td>2006</td>
<td>Direct Chill RheoCasting of High Performance Aluminium Alloys (DCRC)</td>
<td>£2,012,562</td>
<td>Innoval, Alcan, Novels, Brunel, Luxfer Gas Cylinders, Zymax</td>
</tr>
<tr>
<td>2007</td>
<td>Structural Adhesive Bonding of thick Components for Advanced Design (SABCAD)</td>
<td>£693,255</td>
<td>Airbus, BAE Systems, Imperial, Surrey</td>
</tr>
<tr>
<td>2008</td>
<td>Upcycling of Light Alloys by Rheoforming Scrap (ULARS)</td>
<td>£1,614,996</td>
<td>Innoval, Meridian, Norton Aluminium, Zymax and Brunel</td>
</tr>
<tr>
<td>2009</td>
<td>Recyclable Ultra Light Mixed material Automotive Platform (RULMAP)</td>
<td>£768,317</td>
<td>Innoval, IQuad, Atlas Composites, Boal and Oxford</td>
</tr>
<tr>
<td>2010</td>
<td>Lower Cost, Light Weight Vehicles by Increasing the Use of Post Consumer Aluminium Scrap (REALCAR)</td>
<td>£1,908,711</td>
<td>JLR, Novelis, Norton Aluminium, Zyomax, Innoval, Brunel</td>
</tr>
<tr>
<td>2011</td>
<td>Grain refiner for lightweight aluminium automotive castings</td>
<td>£705,418</td>
<td>Grainger &amp; Worrall, ESI-Group, LSM and JLR</td>
</tr>
<tr>
<td>2012</td>
<td>Highly Innovative Technology Enablers In Aerospace</td>
<td>£4,104,789</td>
<td>Jaguar, Caparo, Lotus, MIRA</td>
</tr>
<tr>
<td>2013</td>
<td>Innovative Microstructural Design for Advanced Al Alloys (IDEAL)</td>
<td>£569,453</td>
<td>Rolls-Royce, Aeromet, University of Birmingham</td>
</tr>
<tr>
<td>2014</td>
<td>On-line control of Friction Stir Welding processes Using ultrasonic testing</td>
<td>£980,708</td>
<td>JLR, Innovative, Norton, Brunel University, GKN</td>
</tr>
<tr>
<td>2015</td>
<td>Light weight 7.5 - 12 tonne Future Truck Chassis Concept</td>
<td>£1,252,530</td>
<td>Leyland Trucks, Sapa, MI Technology</td>
</tr>
<tr>
<td>2016</td>
<td>Magnesium Intensive BIW Structures for the Premium Automotive Sector</td>
<td>£1,415,154</td>
<td>Morgan, Pano, MEL, Coventry University, Luxfer</td>
</tr>
<tr>
<td>2017</td>
<td>Hi-TINAL: Advanced High-Tin Aluminium Plain Bearing Alloys</td>
<td>£542,682</td>
<td>Rolls Royce, Brunel, KC Engineering</td>
</tr>
<tr>
<td>2018</td>
<td>Ultra-light Car Bodies (ULCab)</td>
<td>£1,117,026</td>
<td>PAB, Impression Technologies, Lotus, Imperial College</td>
</tr>
<tr>
<td>2019</td>
<td>Novel Aluminium Dross/Salt Slag Press Technology</td>
<td>£626,622</td>
<td>Altek</td>
</tr>
<tr>
<td>2020</td>
<td>High quality surface finished aluminium rollers for mass replication (REPLICAL)</td>
<td>£413,970</td>
<td>Innoval, Macdermid, Stockfield</td>
</tr>
<tr>
<td>2021</td>
<td>A20X High Value Large Structure Casting</td>
<td>£830,300</td>
<td>Aeromet, LSM, JLR, JVM, University of Birmingham</td>
</tr>
<tr>
<td>2022</td>
<td>HITEA: REACH Compliant Hexavalent Chrome Replacement</td>
<td>£2,200,000</td>
<td>Rolls Royce, GE, BAe Systems, Goodrich, Aeroengine Controls</td>
</tr>
<tr>
<td>2023</td>
<td>Compact Lattice structures on Active Membranes</td>
<td>£43,840</td>
<td>Econolyst, Alcan, Avero, Imperial College, Warwick University</td>
</tr>
<tr>
<td>2024</td>
<td>Recyclable aluminium structural casting alloy (RASA)</td>
<td>£1,102,369</td>
<td>Innovate, JMV, Norton, Brunel University</td>
</tr>
<tr>
<td>2025</td>
<td>Innovative Microstructural Design for Advanced Al Alloys (IDEAL)</td>
<td>£569,453</td>
<td>Rolls-Royce, Aeromet, University of Birmingham</td>
</tr>
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Key 2004 - 2010:
- Advanced Materials
- High Value Manufacturing
- Environmental Sustainability

Key 2010 - 2015:
- Technology Inspired Innovation
- Manufacturing
- Resource Efficiency
- Low Carbon Vehicles
- Family Innovative Technology Enablers In Aerospace
TSB active projects (aluminium)

This chart includes collaborative R&D projects with a aluminium and automotive content that have been funded from competitions from 2010 to 2014. The figures represent the total value of the project. TSB typically provides 50% of the funding support inline with state aid rules.
Novel Grain Refiner Partners

**Innoval**
- Project management
- Life cycle analysis

**ESI-group**
- Solidification simulation
- ProCAST modules development

**Jaguar Land Rover**
- Components selection
- Property specification
- Parts testing

**Grainger & Worrall**
- Sand moulds design
- Components casting
- Characterisation

**Brunel University**
- Grain refiner science
- Tests on specific alloys
- Master alloy development
- Scrap recycling simulation

**AMG**
- (Master alloy process up-scaling)

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Grain refiner for high performance lightweight aluminium automotive castings
Grain refiner for high performance lightweight aluminium automotive castings

**Background**

**Publication Details**

- **International Application Number**: WO 2012/110788 A2
- **Priority Date**: 18 February 2011
- **Priority Number**: GB 1102849.5
- **Assignee**: UNIVERSITY; Michael Sterling Building, Kingston Lane, Uxbridge, Middlesex UB8 3PH (GB)
- **Inventors**: NADENDLA, Hari Babu [GB/GB]; c/o Brunel University, Michael Sterling Building, Kingston Lane, Uxbridge, Middlesex UB8 3PH (GB); NOWAK, Magdalena [PL/GB]; c/o Brunel University, Michael Sterling Building, Kingston Lane, Uxbridge, Middlesex UB8 3PH (GB)
- **Agent**: TOLLETT, Ian; Staple Court, 11 Staple Inn Buildings, London, Greater London WC1V 7QH (GB)

**Designated States**


**Publication Information**

Without international search report and to be republished upon receipt of that report (Rule 48.2(g)).
Grain refiner for high performance lightweight aluminium automotive castings

GW116 (A354) with NGR (0.1 Nb-0.1B)

Grain size ~ 2500-3000 μm

Grain size ~ 100-250 μm

Technology Strategy Board
Driving Innovation

Grain refiner for high performance lightweight aluminium automotive castings
REALCAR 2

Mechanical Biological Treatment (MBT)

Aluminium from MBT

EMR Shredder

EMR Media Separation

Coil rolling

DC casting

Aluminium RSIs

Aluminium Melting

Consortium Partners

JAGUAR LAND ROVER

ADITYA BIRLA NOVELIS

ALERIS

THE UNIVERSITY OF WARWICK

Innoval
• EPSRC call
  – £85 Million – Capital for Great Technologies
    • To increase the strength and productivity of the research base by improving the capabilities of the research equipment based in existing technology centres

  – £30 Million for Advanced Materials
    • Individual proposals funded between £3 – 5 Million.
    • To focus in the area of high performance alloys and scale-up facilities for resource efficient processing.
Brunel University has been granted £3.9M from the Engineering and Physical Sciences Research Council (EPSRC) for the creation of a national scale-up facility for automotive light metals research initially in collaboration with Jaguar Land Rover and Constellium. Brunel University will supplement this grant with a further £5.5M for a dedicated building and support resource at their site in Uxbridge.

The goal of the “Advanced Light Metals Processing Research Centre” will be to bridge the gap between fundamental research and industrial applications, allowing rapid exploitation of innovations developed at the laboratory scale.

The Centre aims to provide high-performance light alloys, resource-efficient casting technologies, extrusion processing technologies and component innovations to meet the mid- and long-term needs of the automotive industry.

Of strategic importance will be a fully integrated DC casting and extrusion facility, which is planned to include a full-size 1600 ton extrusion press complete with support facilities and full automation, and commercial scale high pressure and low pressure die casting machines.
Advanced Light Metals Processing Research Centre

Operational Q3 2014: 1300m² approx
Summary

- EPSRC support for aluminium and magnesium is concentrated within LiME, LATEST2, TARF-LCV. These programmes support a large number of RAs and PhDs.
- The Advanced Metallics DTC supports a small number of aluminium PhD projects.
- The support for aluminium research is broadly similar to that of titanium but much lower than the support for PMCs.
- TSB funding to date has supported about 20 aluminium projects to date with a total project value of over £50m.
- Most of the support is for automotive and aerospace related applications.