LIGHT FORM

NEWSLETTER

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The University of Manchester

UNIVERSITY OF CAMBRIDGE

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Introduction

Welcome to the first edition of LightForm News, our regular update on the progress of the EPSRC funded LightForm project.

LightForm is a five-year multidisciplinary project with £4.8m (£5.9 FEC) core support from the EPSRC programme grant scheme, led by The University of Manchester, with partners at the University of Cambridge and Imperial College, London.

Our vision is to provide the enabling science that will allow UK industry to achieve a step-change in the performance of the next generation of wrought, light-alloy, formed components, and innovate in the move to a circular economy, and digital simulation in manufacturing.

We aim to exploit a new holistic manufacturing paradigm, whereby performance and efficiency can be simultaneously increased through intelligently embedding metallurgical design into the manufacturing cycle. LightForm will develop and integrate physical simulations of microstructure and texture evolution with engineering codes, allowing embedded materials engineering to be fully exploited by industry by developing the capability to accurately predict shape and properties in dynamic material systems.

LAUNCH EVENT

Following our launch event at the end of October 2017, which was attended by 62 delegates representing 22 companies across the supply chain, the academic team has been working hard on the ramp-up stage of the project. This has involved recruiting our core Post-Doctoral researchers and meeting with industry to discuss and organise the first phase PhD projects. We are pleased to report that we now have a full team of seven talented researchers with skill sets across modelling, advanced electron microscopy, in situ real-time experimental simulation techniques, forming technology and environmental performance.

In addition, we have recently been joined by Dr Pratheek Shanthraj from the Max Planck Institute Dusseldorf to take up the Airbus Research Fellowship at Manchester. Pratheek is an expert in coupled phase field-crystal plasticity modelling and will work on modelling titanium forging.

Our team now also includes a research software engineer who is working on developing a data management framework for storing and sharing of experimental and modelling data. His role is also to ensure good engineering practice is followed in all software development efforts.

NEW PROJECTS

We have already set up nine new PhD projects and two larger-scale associated projects; one with the Innovate UK programme on the metallurgical underpinning research needed to qualify a high deposition rate, additive manufacturing technology that exploits in-process deformation, and also one developing new thick section Al forging alloys with Otto Fuchs.

In addition, we are in discussion with several forging companies, aerospace manufacturing end users, and the AFRC on the best route forward to developing a large 'MEME' (Manufacturing with Embedded Metallurgical Engineering) programme on using a scientifically informed approach to reducing the cost of producing forged Ti parts, by optimising the process steps.

In this first addition we are pleased to present an overview of our team. If you would like to get involved we welcome contact through our Programme Manager, Natalie Shannon **natalie.a.shannon@manchester.ac.uk**, or direct to the academic team. Please also visit our Website for more detail of the project and up-to-date news.

Phil Prangnell

Aluminium

research theme

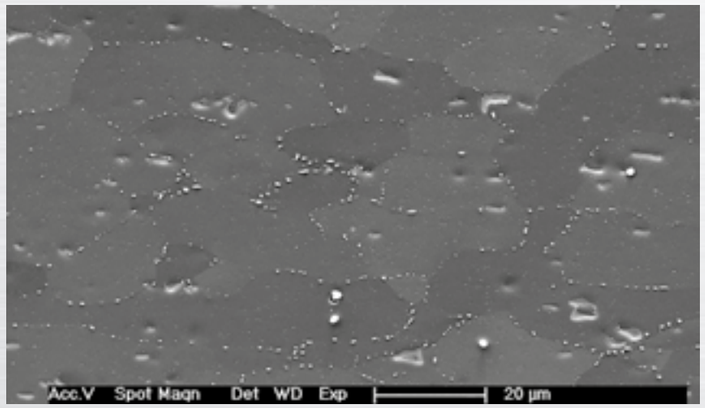
Aluminium alloys are key materials in aerospace applications and are now finding increasing adoption in the automotive sector. In LightForm, the aim of our aluminium research is to exploit our understanding of microstruture evolution and strengthening mechanisms to enable the cost effective forming of high strength alloys. We are interested in two main forming processes: press quenching and warm forming.

In our press quenching research, we are collaborating with our partners Impression Technologies to characterise the microstructure of formed parts, and to understand and predict the microstructure evolution during ageing and its impact on properties and corrosion performance. High resolution SEM and TEM investigations of formed parts are under way, complemented by preliminary corrosion testing. This work will be continued by an Impression Technologies sponsored PhD student starting in September.

The warm forming work is a collaboration with Constellium. It aims to improve our ability to warm form high strength aluminium alloys by studying the effects of microstructure and alloy composition on warm formability. This research will make extensive use of the new Interlaken Forming Press at the Henry Royce Institute. The new press, an Interlaken Servopress 225, will have temperature controlled dies for systematic studies of the effect of forming temperature on formability and microstruture evolution. A PhD project on this topic will also start in September.

These projects are being supported by fundamental work on the interaction between deformation and precipitation during worm forming. We have shown that we can measure the evolution of precipitate volume fraction and size during warm forming using small angle X-ray scattering experiments at the Diamond Light Source and are now planning a programme of experiments to investigate effects of alloys composition, strain path, texture and thermal history.

This experimental work is being supported by computational modelling of formability. We have started work on building a crystal plasticity framework for virtual formability testing and, in parallel, we are developing materials models for forming process simulations, with the aim to improve shape prediction and predict the properties of the formed material.



SEM image showing the microstructure of a warm formed aluminium alloy, showing precipitation at the grain boundaries.

Titanium

research theme

In LightForm, the research on titanium alloy forming is divided into two main areas: predicting the microstructure during hot bulk forming and predicting the ductility (forming limits) of titanium alloys and the hot forming of titanium alloy sheet.

In the bulk forming work we are combining advanced microstructure and mechanical characterisation with computational modelling of deformation and annealing to develop models that can be used to predict microstructure in forged parts using commercially available codes. The ductility research is mostly driven by Rolls-Royce and TIMET and has the aim of understanding how the ductility of an alloy depends on the microstructure of the material. The plan is to use high resolution digital image correlation (HRDIC) to quantify deformation localization at the microstructural scale and then link it to the failure mechanisms via correlative microscopy and micro X-ray tomography. We have recently recruited a PhD for this project, who will start in September. The hot sheet forming work is led by Nan Li at Imperial and aims to use advanced testing and modelling to develop new processes for hot forming of Ti sheet, supported by in-situ experiments.

The advanced characterisation techniques used in Ti alloy research include in-situ measurements of microstructure evolution using synchrotron X-rays, detailed 3D characterisation using electron microscopy, bulk texture measurements using neutron diffraction and thermomechanical simulation using a deformation dilatometer and a Gleeble. The computational modelling effort will address both deformation at the microstructural scale, using crystal plasticity finite element modelling and phase field modelling at Manchester, and at the macroscopic, process scale using finite element modelling at Cambridge.

Our industrial partners in titanium forming research are Rolls-Royce, TIMET, Doncasters and Airbus and also the AFRC. We are working to grow this list and hope to recruit two more PhD students on this topic in the second year of the project.

NEW TEAM MEMBERS

Dr Pratheek Shanthraj

Airbus Research Fellow - Pratheek has 10 years' experience in computational mechanics, microstructure physics and scientific software development at leading institutes in the US, Germany and Japan, he has joined us from the Max-Planck-Institut für Eisenforschung, to take up the Airbus Research Fellowship at Manchester. Pratheek obtained his PhD in Electro-Thermo-Mechanical Modeling at North Carolina State University and is an expert in coupled phase field-crystal plasticity modelling and is the leading developer of the DAMASK (https://damask.mpie.de). He will work on modelling the combined influence of deformation, and phase transformations in two-phase titanium forging.

Dr Jinghua Zheng

completed a PhD in Mechanical Engineering at Imperial College London, during which she developed a constrained ageing technique for residual stress reduction in aluminium aircraft components. She also established and validated physically-based constitutive equations for FE models of residual stress and yield strength distributions in components. Based at Imperial College London, Jinghua's work in LightForm focuses on optimizing and modelling the age hardening response in the HFQ process. This includes an examination of the age hardening properties and considering the effects of prior dislocations. Jinghua will also develop a phenomena-based model to capture the basic ageing mechanisms (i.e. nucleation, growth, coarsening, dissolution of the precipitates) and the interactive relations between ageing and dislocation evolution.

Dr Christopher Stuart Daniel

recently obtained his EngD from the University of Manchester with a thesis on the development of crystallographic orientations (textures) during hot-rolling of dual-phase zirconium alloys. In LightForm, Christopher leads the in-situ characterisation of light alloys and is working to develop in-situ characterisation capabilities for studying the micro-mechanics of deformation at elevated, hot and warm forming temperatures in Ti, Al and Mg alloys, including the development and building of bespoke rigs for use with synchrotron diffraction, neutron diffraction and electron microscopy. Christopher's work is intended to broaden knowledge of the dynamic mechanisms, active during forming, that contribute to the microstructural evolution and precipitate formation during forming of advanced light alloys.

Dr Patryk Jedrasiak

completed an MPhil in Engineering and a PhD in numerical modelling of friction welding at the University of Cambridge, where he is now a Research Associate. Patryk's research experience includes a fellowship at Harvard University, focusing on a novel Eulerian numerical method for simulating elastoplastic solids, 3 years part-time at the industrial sponsor of his PhD, The Welding Institute, as well as undergraduate research placements at Imperial College London and fka Aachen (part of RWTH Aachen). Patryk has also completed internships with Centro Ricerche Fiat, McKinsey & Co., and NATO, working on major engineering challenges: electric vehicles, energy strategy and autonomous systems. Patryk's work with LighForm focuses on microstructure-informed, computationally efficient thermomechanical finite element modelling of innovative forming processes, for light alloys.

Dr Paloma Hidalgo-Manrique

completed a PhD at the Complutense University of Madrid, focusing on the processing of fine-grained microstructures by accumulative roll bonding, and how it can be used to produce material that can be superplastically formed more easily. Since then she has worked on the fundamental deformation mechanisms in Mg alloys as part of LATEST2 and project MAGMAN. Paloma's work in LightForm will extend and optimise the Hot Form Quench (HQF) process in Al alloys, involving a systematic analysis of the effect of different processing parameters on the resulting microstructures and performing detailed characterization of the latter, by a combination of complementary techniques including scanning and transmission electron microscopy.

Dr Adam Plowman

has recently completed a PhD at The University of Manchester, using first principles atomistic simulation to study zirconium grain boundaries, with the aim of understanding the pellet-cladding interaction in the fuel rod cladding tubes of light water nuclear reactors. In LightForm, Adam will create a framework to improve modelling capabilities in assessing the formability of light alloys. This will include exploring crystal plasticity methods and phase field modelling and applying them to predict microstructure development during warm forming and forging.

Dr Alex Cassell

has worked on several research programmes since completion of a PhD on the environmentally assisted degradation mechanisms in light alloys. Working in the Corrosion and Protection Centre he has expertise on the multi-scale characterisation of high performance aluminium alloys. His research has included the study of hydrogen embrittlement (HE) and stress corrosion mechanisms in light alloys, the development of new corrosion protection systems for high performance aerospace aluminium alloys, as well as research on forming techniques for integration of light weight alloy systems into land transport vehicles. Alex's work in LightForm aims to improve our understanding of the degradation mechanisms in high performance light alloys formed using existing and new processes, and their behaviour in demanding environments.

Dr Nicolas Gruel

completed a PhD in astrophysics and a Post-Doc in software development for data acquisition, analysis and simulation of astronomical images. As the lead developer for the Centro de Estudios de Física del Cosmos de Aragón, Nicolas was accountable for creating the data pipeline to analyse 1.4 TB of data per day, moving then to the University of Sheffield where he led the Insigneo Institute Computer Science engineering team. As a Research Software Engineer at The University of Manchester, Nicolas' work involves collaborating with researchers in various fields, such as Humanities, Computer Science and Materials Engineering, supporting their research by managing their software development and/or optimization as well as data management. Nicolas' work in LightForm will be to create a multiplatform data infrastructure to which LightForm data can be uploaded, shared and managed.

Natalie Shannon

has recently joined LightForm as Project Manager, previously the Project Manager for The University of Manchester: Study China programme, a UK government funded programme and the largest China outbound mobility programme delivered in the UK. Natalie has considerable experience in project, operations management and strategic planning, with expertise in the execution of multiple, target-driven contracts, including programmes for Department of Education and Training and Development Agency.

Other news

LightMAT Conference 2019

The 3rd LightMAT Conference and Exhibition on Light Materials – Science and Technology will be held in Manchester from **5th-7th November 2019**

For further information please visit the **LightMat website**

Contact us

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