CaMPUS Placements: UK Industrial - Reports 2019

Below are reports on the Summer Placements provided by students who participated in the scheme in 2019.

Granta Design, Cambridge

1. General		
Placement Location	**ANSYS Granta (formerly Granta Design Ltd)**	
Arrival and Departure Dates	**01/07/2019 – 19/09/2019**	
No. of working days spent at Institution	**46**	
2. Financial		
Where did you stay during your placement (town name)?	**Cambridge (college accommodation)**	
Total cost of daily travel to and from Institution (£)	**0 (bike)**	
Total received from Institution (£)	**£375 per week**	
3. Research Project		
Title of Research Project	**MaterialUniverse Curve Coverage for ANSYS Mechanical**	
Written Report submitted to host institution	**No**	
Experimental Techniques used:	**Excel, ANSYS MAPDL hyperelastic curve modelling**	
Interest level of project	on a scale of 1 (low) to 10(high)	**6**
Quality of support provided	on a scale of 1 (low) to 10(high)	**8**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**7**

Short summary (~ 200 words) of technical content of project:

Granta Design has recently been acquired by ANSYS, an American simulation company, so the main focus of the work at the moment is making Granta products compatible with ANSYS Simulation Software such as Workbench and Maxwell. Earlier in the year, Granta were able to release their first database compatible with ANSYS, known as ANSYS MDS (Materials for Data Simulation). However, the first version of this product had limited curve coverage, particularly for polymers, which limits the modelling that can be done.

The project focused on this mechanical curve coverage for polymers and was divided into three main parts. The first part focused on curve combining, which used an Excel macro to average curves from similar samples in the polymer databases CAMPUS and Prospector to fill some of these gaps in MDS; some analysis on this data was also required, and it was mainly for stress-strain curves. The second part focused on curve modelling, which was an exploration of modelling curves for hyperelastic materials, using ANSYS MAPDL software. This involved some research about hyperelastic models such as Ogden and Mooney-Rivlin and some training from the ANSYS Mechanical Business Unit in America. The third part of the project focused on curve estimation, which aimed to create a tool for estimating stress-strain curves for polymers by analysing trends in data. Some simple analysis was carried out in Excel and then MATLAB was used for multivariable regression analysis.

Side projects included working on a group task for the Global Metals project, involving standardising region names for different samples and creating some new attributes, and also updating medical device descriptions for the MMD database.

Frazer-Nash Consultancy, Dorking, Surrey

1. General	
Placement Location	**Frazer Nash**

Arrival and Departure Dates	**1/7 – 23/8**	
No. of working days spent at Institution	**40**	
2. Financial		
Where did you stay during your placement (town name)?	**Dorking and Bristol**	
Total cost of daily travel to and from Institution (£)	**0**	
Total received from Institution (£)	**£330 per week plus 15 nights' accommodation reimbursed**	
3. Research Project		
Title of Research Project	**Investigation into the economic viability of using Lithium Ion Batteries for Energy Storage by understanding and modelling the degradation mechanisms and possible revenue streams**	
Written Report submitted to host institution	**No, but created slide packs and presented them**	
Experimental Techniques used:	**Modelling in Matlab and Excel**	
Interest level of project	on a scale of 1 (low) to 10(high)	**9**
Quality of support provided	on a scale of 1 (low) to 10(high)	**8**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**8**

Short summary (~ 200 words) of technical content of project:

I investigated the use of large-scale Lithium Ion Batteries for Energy Storage. Their capacity degrades over time and the lifetime is defined when the capacity reaches 80% of its original value. The rate of degradation is affected by several factors, including temperature, charge/ discharge range and the rate of charge/ discharge.

Modelling the chemistry degradation

I researched the degradation mechanisms and investigated different models that have been used to relate battery usage to capacity degradation. I chose a semi-empirical model which I fitted to experimental data in Excel before transferring it to Matlab. I changed different parameters to understand their impact on the lifetime of the battery.

Cost Modelling

I researched the different possible revenue streams a large-scale battery could generate and focused on frequency regulation. Renewable generation does not produce electricity at 50Hz, which is the frequency that the grid is designed to operate at. Batteries can help ensure the frequency remains at 50Hz. I created an integrated degradation and cost model. The cost model accounted for degradation of the battery capacity (using the model created in the first part of the project) and the overall income over the lifetime of the battery was calculated. I then researched current policy regarding batteries for energy storage to understand how the possible revenue streams may change in the future.

TWI, Great Abington, Cambridge

Report 1

1. General	
Placement Location	**TWI, Great Abington, UK**
Arrival and Departure Dates	**22nd July – 20th September**
No. of working days spent at Institution	**45**

2. Financial		
Where did you stay during your placement (town name)?	**Little Shelford**	
Total cost of daily travel to and from Institution (£)	**Roughly £150 in gas money over 9 weeks**	
Total received from Institution (£)	**£3300 in salary**	
3. Research Project		
Title of Research Project	**Use of Photon Counting X ray detectors in K edge imaging**	
Written Report submitted to host institution	**Report on X-ray and Visible Light PC and CI detectors in K edge imaging**	
Experimental Techniques used:	**X ray microscopy, spectral imaging**	
Interest level of project	on a scale of 1 (low) to 10(high)	**6**
Quality of support provided	on a scale of 1 (low) to 10(high)	**7**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**9**
Short summary (~ 200 words) of technical content of project:		
I explored how to identify organic contaminants on MEMS components with an Advapix photon-counting (PC) X ray detector using K edge imaging. Other PC and charge integrating (CI) detectors were tested as alternatives, and a portfolio of images were taken with the Hamamatsu S11685 CI detector to determine its usefulness in further research. Special focus was on the Hamamatsu C13001 visible light PC detector. I was tasked with finding and then determining how to connect 1. A suitable power supply, 2. A scintillating polymer fiber to a standard fiber optic input, and 3. A suitable oscilloscope to the C13001's output. I also researched how a YAG:Ce single crystal fibre could be manufactured. This fibre would absorb higher energy x rays than the polymer alternative, and so could be used in imaging metallic welds (lower energy X rays are used for soft tissue imaging in medicine but are less useful for higher atomic number elements).		

Report 2

1. General		
Placement Location	**TWI, Great Abington, UK**	
Arrival and Departure Dates	**13/7/19-25/7/19**	
No. of working days spent at Institution	**30 days (6 week placement)**	
2. Financial		
Where did you stay during your placement (town name)?	**Central Cambridge**	
Total cost of daily travel to and from Institution (£)	**3.00**	
Total received from Institution (£)	**2098.49**	
3. Research Project		
Title of Research Project	**Shape memory polymers and polymer-based composites with self-healing and self-sensing capabilities**	
Written Report submitted to host institution	**Yes (~13,000 words)**	
Experimental Techniques used:	**None (Literature review)**	
Interest level of project	on a scale of 1 (low) to 10(high)	**8**

Quality of support provided	on a scale of 1 (low) to 10(high)	**8**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**5**
Short summary (~ 200 words) of technical content of project:		
A smart material is one which has an additional functionality extending beyond its principal task (e.g. structural load bearing). Example additional functionalities include sensing, actuation and healing. Specifically, this project examined candidate shape memory polymer composites in which a 'memorised' shape can be recovered from a temporary shape in response to an external stimulus (light, heat, or pH, for example). The mechanism of the shape memory effect in polymers was discussed in detail along with potential applications in the aerospace industry, such as self-actuating hinges or extendable booms. The possibility of making these shape memory polymer composites multifunctional was also evaluated. First evaluated was self-healing, in which the structure can heal cracks and recover strength. This behaviour can be autonomic or in response to an applied stimulus, depending on the self-healing mechanism (determined by microstructure and composition). The other smart functionality assessed for addition to shape memory polymer composites was self-sensing. This is the intrinsic sensing of temperature, strain, pH, and moisture, for example. The self-sensing of strain and damage by detecting the change in electrical resistance in carbon-reinforced shape memory polymer composites was considered in detail. This is of interest due to the susceptibility of carbon fibre reinforced polymers to matrix cracking, which can be difficult to detect in its early stages by other means. There is great promise for these materials, with shape memory polymer composites recently being used in space missions. While the integration of these three smart functionalities was found to be clearly possible, there have been very few published experimental papers in this area. Future research would be required before use in the aerospace industry.		

Johnson Matthey, Royston, Herts.

Report 1

1. General		
Placement Location	**Johnson Matthey Noble Metals, Royston**	
Arrival and Departure Dates	**27/07/19-27/09/19**	
No. of working days spent at Institution	**40**	
2. Financial		
Where did you stay during your placement (town name)?	**Cambridge**	
Total cost of daily travel to and from Institution (£)	**6.00 (average cost for an anytime train return from Cam-Roy)**	
Total received from Institution (£)	**2861.75**	
3. Research Project		
Title of Research Project	**Investigation of Zirconia Grain Stabilized (ZGS) Platinum Wire Produced by Internal Oxidation**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Drawing wire, oxidizing wire in a furnace, mounting/polishing/grinding, tensile testing, hardness testing, stress rupture testing, etching, optical microscopy, SEM and image analysis**	
Interest level of project	on a scale of 1 (low) to 10(high)	**8**
Quality of support provided	on a scale of 1 (low) to 10(high)	**8**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**9**

Short summary (~ 200 words) of technical content of project:
Investigated a new method of producing Zirconia Grain Stabilized Platinum (ZGS Pt) wire by internal oxidation in a furnace. ZGS Pt has superior creep resistance to pure Pt as it contains lots of small Zirconia precipitates that pin dislocations and grain. **Literature on ZGS was reviewed to obtain a better theoretical understanding of the process and which factors would be important to maximize oxidation.** **Initial trials were done to assess the effects of different factors on oxygen including wire diameter, oxygen partial pressure, time of oxidation and temperature of oxidation. Effects of oxidation on tensile strength, hardness and grain structure was measured. Images of grain structure were obtained by etching followed by optical microscopy. These images were then analyzed to measure grain size.** **Following these initial trials, parameters were altered to improve volume fraction oxidized in the final experiment. A design of experiment (DOE) approach was used in the final experiment to understand the effects of different factors to be analyzed and given appropriate weights.** **Zirconia content was analyzed post oxidation with SEM imaging and image analysis using software. Tensile tests and stress rupture tests were conducted on unoxidized wire and both oxidized undrawn (i.e. straight from oxidation) and drawn wire.**

Report 2

1. General		
Placement Location	**Johnson Matthey Noble Metals, Royston**	
Arrival and Departure Dates	**29/07/19-27/09/19**	
No. of working days spent at Institution	**39**	
2. Financial		
Where did you stay during your placement (town name)?	**Cambridge – college accommodation**	
Total cost of daily travel to and from Institution (£)	**~£250**	
Total received from Institution (£)	**~£3000**	
3. Research Project		
Title of Research Project	**Powder Characterisation and production**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Qicpic particle size analyser, Freeman FT4 powder rheometer, SEM, powder production equipment**	
Interest level of project	on a scale of 1 (low) to 10(high)	**9**
Quality of support provided	on a scale of 1 (low) to 10(high)	**9**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**7**
Short summary (~ 200 words) of technical content of project:		
I worked on several different research based and experimental projects relating to metal powders. All of project strands were to help with wider R&D team progress. I contributed to the detailed planning of an experiment investigating a production technique used at JM and designed the data collection method for this experiment. Characterisation of various metal powders was carried out to measure their flow properties and particle size distribution. **I made spreadsheets for capturing data from the powder rheometer so it could be used for future tests.**		

I reviewed relevant existing products to enhance technical understanding of them and I also reviewed how powder charcterisation techniques have been used by others in the past. Off the back of this, I planned a powder characterisation experiment that was carried out in collaboration with an industrially sponsored PhD student.

AIXTRON, Swavesey, Cambridgeshire

Report 1

1. General		
Placement Location	**AIXTRON, Swavesey**	
Arrival and Departure Dates	**1st July – 27th September**	
No. of working days spent at Institution	**59**	
2. Financial		
Where did you stay during your placement (town name)?	**Cambridge**	
Total cost of daily travel to and from Institution (£)	**£7**	
Total received from Institution (£)	**5112.00 (before tax)**	
3. Research Project		
Title of Research Project	**Graphene Characterisation Techniques**	
Written Report submitted to host institution	**Presentation of 30mins-1hr was the requirement**	
Experimental Techniques used:	**Raman, AIXTRON tools, 4-point probes, microscopy.**	
Interest level of project	on a scale of 1 (low) to 10(high)	**7**
Quality of support provided	on a scale of 1 (low) to 10(high)	**6**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**8**

Short summary (~ 200 words) of technical content of project:

The brief was to help create methods of graphene characterisation on both copper and polymer substrates. The first item I acquired for this was a 4-point probe. Pristine CVD graphene has a sheet resistance of ~900ohms/square so any variation in this number is due to a lack of quality, coverage or uniformity all of which have an impact on the usefulness of the graphene for that application. This was for use on non-conductive substrates as Raman spectroscopy can't be used on the PET and similar polymer substrates nano was using. Also Raman had significant issues identifying uniformity and coverage since the spot size is so small.

The next was a camera system focusing on high contrast region specific imaging. The system was acquired from Navitar and built by me on site. This system is able to produce extremely high contrast images of the copper substrate and can potentially in conjunction with some software be used to identify graphene on copper in-line on the R2R (roll to roll) system. On top of that I had a very varied set of things to do, including but not limited to:

- **Testing oxidation resistance of copper coated in graphene.**
- **Research on applications and industry specific markets for graphene.**
- **Corrosion resistance of stainless steel substrates.**
- **Transfer testing of graphene between PET/EVA to a thermal silicon oxide wafer.**

Report 2

1. General		
Placement Location	**Swavesey, Cambridgeshire**	
Arrival and Departure Dates	**24.06.2019-30.08.2019**	
No. of working days spent at Institution	**45**	
2. Financial		
Where did you stay during your placement (town name)?	**Cambridge**	
Total cost of daily travel to and from Institution (£)	**£4.00 (petrol)**	
Total received from Institution (£)	**£4000**	
3. Research Project		
Title of Research Project	**Optimisation of monolayer hBN growth**	
Written Report submitted to host institution	**Submitted**	
Experimental Techniques used:	**MOCVD (Metal Organic Chemical Vapour Deposition)**	
Interest level of project	on a scale of 1 (low) to 10(high)	**5**
Quality of support provided	on a scale of 1 (low) to 10(high)	**5**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**4**

Short summary (~ 200 words) of technical content of project:

My project was to optimise, grow and characterise single crystal hBN (hexagonal boron nitride) using AIXTRON MOCVD (Metal Organic Chemical Vapour Deposition) equipment. Monolayer hBN is extremely interesting for microelectronics because it is an atomically thin and flat insulator; the ability to grow single crystal hBN directly on wafers is a key technological challenge that needs to be overcome for hBN integration into electronics. A literature survey revealed that large, single crystals of hBN have been successfully grown on metal catalysts previously; however, this method is limiting because the hBN is on a metal surface and needs to be removed to be used.

In this project, the direct growth of hBN crystals/triangles directly onto sapphire wafers is demonstrated using MOCVD without the need for any metal catalyst. Multiple growth modes of hBN have been observed under various growth conditions and characterised using Peak Atomic Force Microscopy. Triangular and hexagonal spirals crystals of hBN were observed directly on sapphire, as well as nucleation of hBN multilayer films.