European Vacation Placements: Reports 2023

Below are reports on the Summer Placements provided by students who participated in the scheme in 2023.

ETH, Zurich, Switzerland

1. General		
Placement Location	**ETH, Zurich, Switzerland**	
Arrival and Departure Dates	**08.07.23-02.09.23**	
No. of working days spent at Institution	**38**	
2. Financial		
Cost and method of return travel from the UK (£)	**I live in Heidelberg, Germany. Therefore, I first went back home from Cambridge and then travelled from Heidelberg to and from Switzerland and then back to the UK. I did this by train and used an interrail pass. The cost of the pass, reservations, and additional trains (you can only use the trains in your home country on two days) amounted to 410 Euros or approximately £350.**	
Total cost of daily travel to and from Institution	**£0** **I travelled either by bike or with the free ETH Link bus.**	
Total cost of accommodation (say if provided free)	**2400 CHF or £2150 pounds**	
Value of Armourers & Brasiers bursary	**£1670**	
Total received from College	**0**	
Total received from Institution	**1100 CHF or £980**	
3. Accommodation		
Accommodation address	**Sonneggstrasse 31, 8006 Zürich, Switzerland**	
Type of Accommodation	**Room in a shared apartment**	
Distance from Institution	**5km, about 20 minutes by bike or 15 minutes by bus**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**8**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**7**
Convenience of location	on a scale of 1 (low) to 10 (high)	**10**
4. Research Project		
Title of Research Project	**Fuel-dependent steering of catalytic microswimmers by obstacles**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Nano 3D Printer, Optical Microscopy, TrackPy, ImageJ**	
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)	**10**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**9**
Short summary (~ 200 words) of technical content of project:		
Catalytic microswimmers are artificial agents that self-propel via catalytic decomposition of a fuel, for example hydrogen peroxide. This is of interest in healthcare (for example drug delivery) and		

environmental mediations. To develop applications, understanding the interaction between swimmers and obstacles is key. This is where my project came into play.

The aim of the project was to investigate the interactions between swimmers and obstacles, dependent on the surface geometry and fuel concentration. The particles were Silica Janus particles with a hemispherical platinum coating. I used a nano 3D printer to print a micronsized array of structures such as ellipses, pillars, and flat top cones. Then, I conducted experiments to see how the particle behaviour changed with fuel concentration but also obstacle parameters such as height and curvature. For example, the particles' ability to orbit around pillars increases with fuel concentration and pillar radius. I used my findings to design more complex structures such as ladders with steps of different heights and inclinations.

My project involved everything from printing the structures to carrying out the experiments and doing data analysis. I captured videos of the particles using an optical microscope and edited them in ImageJ. To analyse their trajectories and velocities I wrote custom python scripts. The structures were designed in FreeCAD.

Paul Scherrer Institute, Villigen, Switzerland

1. General		
Placement Location	**PSI, Villigen, Switzerland**	
Arrival and Departure Dates	**10 July to 01 September**	
No. of working days spent at Institution	**8 weeks with 3.5 days off (36.5 days)**	
2. Financial		
Cost and method of return travel from the UK (£)	**£300 (Easyjet to Zurich + train + bus, with bike box)**	
Total cost of daily travel to and from Institution	**Free, 2 minute walk**	
Total cost of accommodation (say if provided free)	**£1500**	
Value of Armourers & Brasiers bursary	**0**	
Total received from College	**0**	
Total received from Institution	**£3000**	
3. Accommodation		
Accommodation address	**Guesthouse, Paul Scherrer Institut, WGHA PSI, 5234 Villigen, Switzerland**	
Type of Accommodation	**Onsite guesthouse**	
Distance from Institution	**2 minute walk**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**8**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**8**
Convenience of location	on a scale of 1 (low) to 10 (high)	**10 (for work)** **4 (for anything else)**
4. Research Project		
Title of Research Project	**Analysis of the growth of pores in the additive manufacturing of alumina by a convolutional neural network**	

Written Report submitted to host institution	**Yes**	
Experimental Techniques used:		
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)	**9**
Short summary (~ 200 words) of technical content of project:		
To use a neural network to identify pores and cracks in tomograms of 3D printed alumina samples. **This required manual segmentation of a small amount of training data which was then fed into the neural network and used to train it. Lots of time was spent optimizing the learning rate and training data to give the best outcome. I then used python to analyze the resulting data about the pores, trying to determine how they evolve over time and potential mechanisms for growth during SLM.** **Alongside this I spent time in the lab helping construct a new iteration of the SLM. In the final few days, we used this machine at the synchrotron. This consisted of hours of printing new layers whilst recording the X-ray diffraction pattern to see the evolution of the structure as the laser passes through. The cooling rate can also be extrapolated from the shifts of the peaks.**		

EMPA, Thun, Switzerland

1. General		
Placement Location	**EMPA, Thun, Switzerland**	
Arrival and Departure Dates	**01/09/2023 - 17/09/2023**	
No. of working days spent at Institution	**55 days**	
2. Financial		
Cost and method of return travel from the UK (£)	**Flights to/from Geneva: £133.08 + £130 for bike** **Train from/to Geneva: CHF34.40+40.80**	
Total cost of daily travel to and from Institution	**0 (free public transport card from Lab Hotel, or cycling)**	
Total cost of accommodation (say if provided free)	**CHF850 per month, paid for by EMPA directly**	
Value of Armourers & Brasiers bursary	**£700**	
Total received from College	**£200**	
Total received from Institution	**CHF750 per month**	
3. Accommodation		
Accommodation address	**THE LAB HOTEL, Mönchstrasse 37, 3600 Thun, Switzerland**	
Type of Accommodation	**Student halls (ensuite hotel room)**	
Distance from Institution	**4km**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**9**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**7**
Convenience of location	on a scale of 1 (low) to 10 (high)	**8**
4. Research Project		

Title of Research Project	**Trials & Tribulations with Atomic Layer Deposition**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Atomic layer deposition, Ellipsometry, X-ray reflectometry, SEM**	
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)	**10**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**8**
Short summary (~ 200 words) of technical content of project:		
In broad terms, the project focused on setting up the Swiss Cluster atomic layer deposition (ALD) apparatus for the deposition of alumina and zinc oxide films. Although the films themselves were not of much research interest, I developed a strong understanding of the process and the equipment, as well as gaining experience in ellipsometry, X-ray reflectometry, and electron microscopy as analytical techniques. Beyond that, I read, presented, and discussed relevant literature on both "normal" thermal ALD, and the plasma-enhanced variant, and learnt something about related research including sputtering, and time-of-flight mass-spectrometry. **The overall theme of my project became a holistic understanding of the calibration process, trying to work out the relative merits of different approaches and which elements of setting-up an ALD process are necessary, and which are merely prudent.**		

TUHH, Hamburg, Germany

1. General		
Placement Location	**TUHH, Hamburg, Germany**	
Arrival and Departure Dates	**01.07.2023 to 31.08.2023**	
No. of working days spent at Institution	**35**	
2. Financial		
Cost and method of return travel from the UK (£)	**£231.22, plane travel with Ryanair**	
Total cost of daily travel to and from Institution	**£62.31**	
Total cost of accommodation (say if provided free)	**£531.52**	
Value of Armourers & Brasiers bursary	**£224.40 upfront, £100 after report submission**	
Total received from College	**£0**	
Total received from Institution	**£508.09**	
3. Accommodation		
Accommodation address	**Weinligstraße 21, 21073 Hamburg, Germany**	
Type of Accommodation	**Spare room in a family's house**	
Distance from Institution	**600m**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**7**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**9**

Convenience of location	on a scale of 1 (low) to 10 (high)	**10**
4. Research Project		
Title of Research Project	**Production and measurement of tough ceramic-polymer composites**	
Written Report submitted to host institution	**yes**	
Experimental Techniques used:	**Wet chemistry, use of hot press, use of automatic cutting machine, 3-point bending tests, Vickers indentation, optical and scanning electron microscopy, use of centrifuge, use of sonicator, use of DLS, use of TGA**	
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)	**10**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**10**
Short summary (~ 200 words) of technical content of project:		
The project involved creating samples of a ceramic-polymer composite – a material where ceramic particles were linked together using polymer chains. **This involved wet chemistry for the initial bonding of the ceramic and polymer, and then a sonicator, centrifuge, hot press, and cutting machine were used to produce bars of this material.** **These bars were then tested using a 3-point bending test, and a Vickers hardness test. They were also analysed with optical and scanning electron microscopy, thermal gravimetric analysis (TGA) and dynamic light scattering (DLS) to determine their properties and final composition.**		

Helmholtz-Zentrum Hereon, Geesthacht, Germany

1. General	
Placement Location	**HZH Geesthacht, Germany**
Arrival and Departure Dates	**15/07/2023 – 14/09/2023**
No. of working days spent at Institution	**41**
2. Financial	
Cost and method of return travel from the UK (£)	**Trains from Karlsruhe to Hamburg (outward) and Hamburg to Oxford (return), plus bus travel between Hamburg and Geesthacht** **Total: £216.95**
Total cost of daily travel to and from Institution	**£0**
Total cost of accommodation (say if provided free)	**€840**
Value of Armourers & Brasiers bursary	**£870**
Total received from College	**£0**
Total received from Institution	**£1490.75**
3. Accommodation	
Accommodation address	**Otto-Hahn Strasse 1, Geesthacht 21502, Germany**
Type of Accommodation	**Guesthouse (24 residents total, ensuite room, shared kitchen)**

Distance from Institution	**10 minute walk**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**9**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**7**
Convenience of location	on a scale of 1 (low) to 10 (high)	**6 (near workplace, otherwise in the middle of nowhere)**
4. Research Project		
Title of Research Project	**The effects of varying strain rate on the deformation behaviour of Mg-10Gd as investigated by acoustic emission and in-situ synchrotron diffraction**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Preparation of metallographic samples, optical microscopy, SEM. Data analysis of synchrotron diffraction and acoustic emission experiments (carried out before my arrival).**	
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)	**7**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**8**
Short summary (~ 200 words) of technical content of project:		
Optical microscopy, SEM and EDX were performed on as-extruded Mg-10Gd to characterise its initial microstructure. Tensile tests at four different strain rates had been performed on this alloy at the Deutsches Elektronen-Synchrotron (DESY), with electron diffraction and acoustic emission (AE) measurements (AE data could only be obtained for the higher three strain rates). Microstrain and intensity on certain diffraction planes were calculated from the diffraction data, while cluster analysis was performed on the acoustic emission data to give information on the time evolution of dislocation glide and twinning (the two main plastic deformation mechanisms in Mg alloys) throughout the tests. **Macroscopic stress-strain curves showed a monotonic increase in both ultimate tensile stress and strain to failure with strain rate (the first was expected, the latter unusual). The electron diffraction results showed twinning beginning around macroscopic yield. The AE data showed three regions of deformation behaviour at all strain rates: dislocation glide is dominant during the first and third regions, while in the middle twinning (beginning around macroscopic yield) is dominant. Twinning becomes more prevalent as strain rate increases and takes up a larger portion of the test's duration.**		

Max Planck Institute für Eisenforschung, Düsseldorf, Germany

Report 1

1. General	
Placement Location	**MPIE, Düsseldorf, Germany**
Arrival and Departure Dates	**01/07/23 – 01/09/23**
No. of working days spent at Institution	**44 days**
2. Financial	
Cost and method of return travel from the UK (£)	**£279.98 flying with Eurowings**
Total cost of daily travel to and from Institution	**€100 2x Deutschland Ticket valid for all regional transport in Germany**

Total cost of accommodation (say if provided free)	**€850 per month plus €100 cleaning fee**	
Value of Armourers & Brasiers bursary	**£1500**	
Total received from College	**£400**	
Total received from Institution	**€1400**	
3. Accommodation		
Accommodation address	**Morsestraße 9, 40215 Düsseldorf, Germany**	
Type of Accommodation	**Studio**	
Distance from Institution	**30 mins by tram**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**7**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**7**
Convenience of location	on a scale of 1 (low) to 10 (high)	**10**
4. Research Project		
Title of Research Project	**Mechanical Properties and hydrogen embrittlement of CoCrFeNi with TiN and TiO_2 nanoparticle additions**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Nanoindentation, electrochemical charging, dark field optical microscopy and wire saw cutting, grinding and polishing of metal samples**	
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)	**9**
Interaction with other researchers	on a scale of 1 (low) to 10 (high)	**10**

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

The two samples I was presented with were printed with exactly the same printing parameters and matrix via Laser Powder Bed Fusion (LPBF). Significant microstructural differences arise from the different nanoparticle additions with TiN 800nm additions resulting in areas of large grains (cubes) separated by channels of sub-micron grains and thin grains perpendicular to each other that trace out the path of the laser (channels). TiO2 <5µm additions, on the other hand, demonstrate equiaxed grains.

The mechanical properties of the channel and cube microstructure were probed by creating a hardness map from an array of nanoindentations and comparing it to EBSDs of the indented region to assign the indents. It was found that the channels while initially slightly stronger without nanoparticle additions after the addition of TiN 800nm 0.5vol% become slightly weaker.

When TiO2 nanoparticles are added the channel and cube microstructure is no longer seen as the lower melting temperature of TiO2 leads to greater convection and mixing when the laser scans through the sample leading to equiaxed grains.

Upon hydrogen charging overall softening is observed in TiN-containing samples with cubes undergoing more softening than the channels.

There are questions over the diffusivity of hydrogen within samples of both kinds of nanoparticle additions hence more tests have to be done to investigate whether TiO2 containing CoCrFeNi interacts with hydrogen via a completely different mechanism resulting in an increase in hardness.

Report 2

1. General		
Placement Location	**MPIE, Düsseldorf, Germany**	
Arrival and Departure Dates	**01/07/23 – 01/09/23**	
No. of working days spent at Institution	**39**	
2. Financial		
Cost and method of return travel from the UK (£)	**Flights (Eurowings), 116GBP**	
Total cost of daily travel to and from Institution	**Monthly travel pass for 49EUR/mo, including all regional transport throughout Germany**	
Total cost of accommodation (say if provided free)	**850EUR per month + 100EUR cleaning fee at the end**	
Value of Armourers & Brasiers bursary	**£1500**	
Total received from College	**Up to £66 reimbursement for travel to/from Heathrow, based on receipts shown afterwards**	
Total received from Institution	**1400EUR for 2 months**	
3. Accommodation		
Accommodation address	**Morsestr. 9, 40215 Dusseldorf**	
Type of Accommodation	**Private apartment**	
Distance from Institution	**30 mins on public transport**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**9**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**9**
Convenience of location	on a scale of 1 (low) to 10 (high)	**7**
4. Research Project		
Title of Research Project	**Synthesis of Ga@MoOx core-shell liquid metal nanoparticles**	
Written Report submitted to host institution	**Yes**	
Experimental Techniques used:	**Ultrasonication, basic chemistry wet lab work, TEM, SEM**	
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)	**7**
Short summary (~ 200 words) of technical content of project:		
Gallium has a low melting point for a metal of ~30 °C and is therefore considered a liquid metal (LM) at room temperature. LMs and especially LM nanoparticles are used in many applications including flexible electronics, self-healing circuits, microfluidics, and catalysts. **I synthesised liquid metal core-shell nanoparticles by ultrasonicating bulk gallium to form gallium nanoparticles, which works because the shear forces from ultrasonication cause the gallium to disperse into small droplets. The particles' size distribution was checked under TEM and analysed to investigate the duration of ultrasonication required to obtain an adequate size distribution. These were then reacted with Na2MoO4 in a galvanic replacement reaction. The molybdate ions react with gallium and form a shell of solid amorphous, porous molybdenum oxide around the liquid gallium core. The Ga@MoOx core-shells were observed and characterized in TEM, STEM, and EDS. The thickness of the shell formed**		

depends on the original size of the particle. I had the opportunity to operate TEM and SEM machines myself, and learnt how to take images and process data, including STEM, EDS, and diffraction patterns.

MUL, Leoben, Austria

1. General		
Placement Location	**MUL (Erich Schmidt Institute), Leoben, Austria**	
Arrival and Departure Dates	**01/07/2023 – 28/08/2023**	
No. of working days spent at Institution	**40**	
2. Financial		
Cost and method of return travel from the UK (£)	**£173 (plane + train)**	
Total cost of daily travel to and from Institution	**£0**	
Total cost of accommodation (say if provided free)	**€1058 (+ €550 refundable deposit)**	
Value of Armourers & Brasiers bursary	**£1340**	
Total received from College	**£0**	
Total received from Institution	**€4086 before local taxes**	
3. Accommodation		
Accommodation address	**Milestone Leoben, Schießstattstraße 9, Leoben**	
Type of Accommodation	**Student accommodation - 1 room apartment**	
Distance from Institution	**10 mins walk**	
Quality of accommodation	on a scale of 1 (low) to 10 (high)	**9**
Quality of facilities	on a scale of 1 (low) to 10 (high)	**8.5**
Convenience of location	on a scale of 1 (low) to 10 (high)	**10**
4. Research Project		
Title of Research Project	**Ex situ nanoindentation of HPT deformed NbTiZr alloys**	
Written Report submitted to host institution	**Yes, and presented the results orally as well**	
Experimental Techniques used:	**Ex situ nanoindentation, micromechanical specimen preparation, data analysis with Python**	
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)	**10**
Interaction with other researchers	on a scale of 1 (low) to 10(high)	**9**
Short summary (~ 200 words) of technical content of project:		
HPT, or high-pressure torsion, enables the production of extremely fine-grained materials. Their small grain size leads to both enhanced strength and toughness, which are sought after properties in many materials. To investigate the mechanical properties of such alloys, nanoindentation can be used to gain data about the stiffness, hardness and strain rate sensitivity (among others). The last of these contains direct information about the main deformation mechanisms present in the material. While usually done in situ, an ex situ nanoindentation setup could be much easier and faster when the precision of an SEM is		

not required. For this experiment, optical cameras proved sufficiently precise, and the benefits of the setup were thus shown. Analysis of nanoindentation data is also a difficult task – to this end, a suite of graphical user interfaces was made in Python to help with data analysis and automate most of the steps.

Several smaller projects were also undertaken over the course of the placement, including the analysis of the structure and properties of kidney stones, which involved microhardness measurements and imaging using a scanning confocal microscope, and analysis of indents from a different experiment, which again involved the confocal microscope, and also image processing to determine anisotropy of the indent shape.