Hammermen Scholarship 2023

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In August 2023 the Hammermen of Edinburgh provided me with the opportunity to travel and experience real-world engineering developments relating to my degree as a mechanical engineer. I used this opportunity to travel to Dresden, Germany, for 10 days and take part in the Fraunhofer IWS 12th international summer school. Fraunhofer is an innovative German organisation that strives to research and develop future technologies that can shape our industries. The Institute for Material and Beam Technology (IWS) has their focus on laser based applications for material processing, developing systems for purposes such as aerospace, energy, mechanical engineering and medical applications. The summer school was done in collaboration with the Technical University of Dresden, and was a workshop based around the "Trends and New Developments in Laser Technologies".

This subject area is of particular interest to me as it relates to the work I have previously carried out during my dissertation, where I looked at the laser welding of small 3D geometries. This summer school gave me an opportunity to see some of the more advanced processes in this discipline, and talk to others who share similar interests.

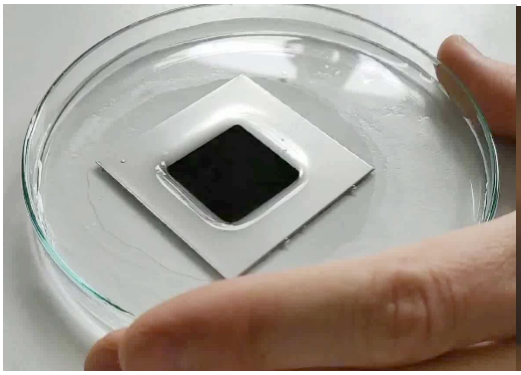
Whilst I am not yet sure what field of engineering I would specifically like to pursue on completion of my degree, the Hammerman scholarship has given me an invaluable opportunity to explore real industry developments in a relevant area. It has given me useful insight into the engineering research and manufacturing industry, as well as a chance to speak to those currently working in such fields.

As part of my visit to Germany, I also had the chance to explore the city of Dresden and the surrounding area, and immerse myself in the culture of the city whilst learning about its rich history. Exploring some of the famous landmarks across Dresden, as well as the striking scenery whilst travelling along the Elbe river.

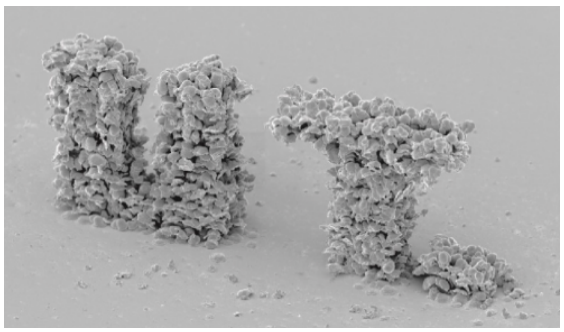
The summer school took place at Fraunhofer's Material and Beam Technology research facility over the course of a week. There were around 50 other participants involved in the program, ranging from PhD students, researchers, industry professionals, and sponsors – many of whom travelled from all over Europe to participate. Over the course of the week interesting talks were given by both professional speakers and those participating in the summer school, explaining the research they had been carrying out. There was a range of themes explored, including: micro processing techniques, processing for material functionality, process monitoring, laser cutting, additive manufacturing, and optics and scanner systems.

Micro processing techniques primarily involved different surface ablation techniques, capable of processing different materials to influence their surface properties. A series of studies investigated the use of femtosecond lasers to remove material from the surface of an object, allowing characteristics such as corrosion and wettability to be controlled. Using femtosecond lasers allows higher quality results to be achieved on a wider range of materials, which is crucial for their application across various industries. The main issue faced by such surface processing techniques is balance between resolution and throughput. A recent development that I found interesting which tackles this problem is direct laser interference patterning (DLIP); by overlapping coherent laser beams an interference pattern can be generated in order to form sub micro-meter features on the surface of a material. Fraunhofer

has demonstrated the use of this technology with the production of super hydrophobic surfaces and structural colour fabrication.



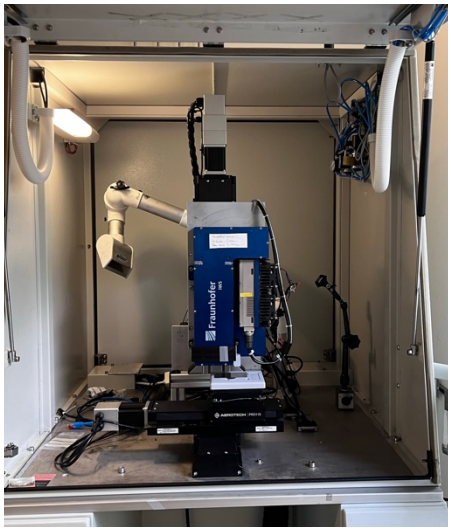
A microfabrication technique for material functionalization that has gained more attention in recent years is the use of Laser-Induced Forward Transfer. This practice essentially allows for the microscopic 3D additive manufacturing and has the potential to be used with almost any material. It does so by precisely depositing small amounts of material from a carrier surface onto a receiver surface with the use of a laser. On the underside of a transparent carrier surface, a donor material is held; when the laser action is applied to this donor material, it propels a small amount of the material to the surface below. By repeatedly using this mechanism to transfer material, small 3D structures can be built up, and with the addition of sacrificial support material more complex geometries can be produced. I found the working principle of this mechanism very interesting, as it opens the door to generating microscopic electronics, tiny thermocouples and even micro tweezers.



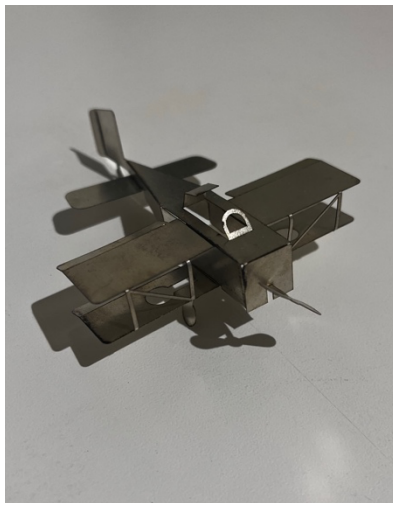
Recent developments in additive manufacturing (AM) was a particularly interesting topic to me as an engineer, and gave me insight into the future of prototyping and production that allows for new types of designs not previously achievable. Fraunhofer has been developing technology to take advantage of this largely untapped area of the manufacturing market, and putting new systems to the test. The type of additive manufacturing that was presented focused on laser based approaches such as laser powder bed fusion (LPBF) and laser material deposition (LMD). Both of these techniques use a laser to melt material and built up a 3D part layer by layer, with LPBF using a bed of powder to do so whilst LMD directly deposit layers of material onto a substrate. The advent of such technology has allowed for much more complex components to be made with internal structures, optimised topology, multi-material designs, function integration and a high degree of customisation.

Images courtesy of presentation slides

As part of the summer school, Fraunhofer gave us a tour of their facilities and an opportunity to see some of the technology they were working on. Firstly, we were given a demonstration of the DLIP technology that has been developed for commercial use. Looking at samples produced by this technology under a microscope it was clear to see the periodic interference pattern generated, as well as the effect of different laser parameters in the material removal process. To give us some better insight into how this interference pattern is generated from a single beam, we got a chance to set up the experiment ourselves. Using a series of beam splitters, polarisers and positioning jigs, we were able to generate similar interference patterns in a optics bench setup, and it was interesting to see the relatively intuitive process of creating such patterns.



Our second lab involved a demonstration of the laser cutting process wherein the setup made use of a fibre laser and galvo scan head to quickly process material. Repeatedly lasing a pattern onto the target rapidly and accurately removes material from the workpiece. This type of setup is versatile, as there is no limit to the output geometry of the galvo scanner, furthermore the setup can be used on a wide range of materials. For our experiment we cut out small origami like planes from thin stainless steel, which only took a matter of seconds to produce each time.



Finally, the third lab gave us an opportunity to see some of the additive manufacturing processes that are being carried out at Fraunhofer. One of their workshops contained several large AM processing machines, and getting to see these machines working up close was a great opportunity to learn about the processes and some of the key considerations that go into their design and operation. We were also given the chance to see a wire LMD machine producing a part, wherein a thermal imaging camera highlighted the difference in layer temperature as the process progressed. A powder LMD machine was also shown to us, allowing us to see the different systems that are carried on the head of the machine in more detail. A robotic arm holds a specially designed nozzle is able to deliver the mix of powders, shielding gas and laser beam. This technology has been used by Fraunhofer to produce a large satellite component for NASA, which took upwards of 6 months of continuous machining to manufacture. One particular machine combined the powder LMD technology with CNC machining; this is used to dramatically reduce the manufacturing time for impellors, whilst only requiring minimal post processing. The final AM technology shown to us was LPBF. As well as seeing these machines in operation we were shown some parts that had been produced by this technology.

Using this technology produces much higher resolution components compared to the previous techniques. One such component is a compliant mechanism that allows for a change in rotational movement in a single component with frictionless motion. Whilst I wasn't able to take pictures of all the technology being developed, there were still some interesting pieces that I have been able to share.

Getting the opportunity to attend this summer school with the Hammermen scholarship has been a fantastic experience, both to learn and meet others sharing similar interests. As well as professional talks, I got an opportunity to hear some presentations from other students on the research that they had been carrying out. This gave me the opportunity to engage with them about their work, and understand the diverse range of topics explored amongst the academic community. It was a great chance to share experiences, challenges and ideas, and get a better understanding of the future developments in this field.

During my time in Dresden I also had the opportunity to explore the beautiful city and its surroundings. The historically significant city has a long history of royal residence for the Kings of Saxony, who built up Dresden with beautiful architecture and majestic buildings. I spent a couple of days exploring the city and visiting some of the historical buildings, such as the Zwinger and Frauenkirche. The Zwinger is a grand palace complex containing a garden and series of museums. Whilst the gardens were under maintenance at the time of my visit, I still got the opportunity to explore the palace and visit the Museum of Maths and Physics located within its grounds. The museum contained some of the early developments in optics and telescopes, as well as various other scientific instruments.

During the end of the second world war, much of Dresden's city centre was completely destroyed, however restoration efforts have brought the area back to life. One such example of this is the Dresden Frauenkirche ("church of our lady"), reconstructed between 1994 and 2005. Much of this building was reconstructed using the original brickwork which can be seen by the variation in colour throughout the building. Visiting the top of this building I was able to get an impressive view of the city, and the Elbe river that makes its way through the town.

Speaking with some of the local students from the summer school also gave me some insight into areas of the city worth exploring, and led me to see the Procession of Princes – a long mural of the rulers of Saxony from 1127 to 1904. The artwork is made of around 23,000 Meissen tiles and is the largest porcelain artwork in the world.

The Zwinger

The Dresden Frauenkirche

View from Frauenkirche

Procession of Princes

Bastei Bridge

Keen to explore much of the surrounding area, I took myself to the Saxony national park to go on a hike and visit the Bastei rock formations and bridge. Venturing within the park led me through some impressive ravines to emerge in the sandstone mountains. Many of these vast rock pillars stretched across the national park. I was able to climb one of these pillars allowing me to get a better feel for the scale of the formations (which was nearly 200m higher than the river where I started). My route also took me across the Bastei bridge, a spectacular structure connecting several of these rock pillars.

On my final day in Dresden I took some time to relax and headed on a steam boat to the nearby town of Meissen. This small town located on the banks of the river Elbe is famous for its manufacture of porcelain, as it was the first to produce high quality porcelain within Europe. The porcelain factory was originally inside the impressive Albrechtsburg Castle, which was first built in 1495 as a royal residence, and is now a museum revealing its history. I also took the time to explore the adjacent cathedral and quaint streets of the small town, which was a great opportunity to learn about the area.

Whilst on the steamboat, it was interesting to see the inner workings of the steam ship as it sailed along. Steamboats have been a feature of the Elbe river since the mid-1800s and allowed for better connection between towns such as Meissen, and taking the opportunity to explore the region on these was a wonderful end to my time in Dresden.

Steamboats

Albrechtsburg Castle

During my trip, and over the course of the Fraunhofer summer school, I have been able to grow my knowledge of engineering, meet some fantastic like-minded people, and experience the rich history of Dresden. I am extremely grateful to have been given such a fantastic opportunity by the Incorporation of Hammermen, and to have taken part in a remarkable program organised by Fraunhofer. This experience has broadened my perspective on the diversity of the engineering field, and the variety of ways in which I may be able to contribute in the future. It has allowed me to not only further my understanding of current and future laser based technology but also witness the process of turning concepts into functional systems. This trip has expanded the horizon of my future goals, and I can see myself becoming part of this dynamic field in the future.