

Can selective laser melting Additive manufacturing be a commercially viable manufacturing method for an SME in the luxury and precious metal industry in South Wales and what barriers does the jewellery industry need to overcome to use this Manufacturing method?

Is selective laser melting additive manufacturing commercially viable in the South Wales precious metals industry and what are the barriers?

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Chapter 1- Introduction

- Provide preliminary background information that puts your research in context.
- Clarify the focus of your study.
- Key research questions
- Why is this research important?
- What do I expect to find because of my research?
- Point out the value of your research (including secondary research)
- Specify your specific research aims and objectives.
- Write about yourself and your involvement in DCW
- Factors that impacted on the DCW project – that were successful and other that caused the project to fail.

The Luxury Jewelry Market Size is valued at USD 78,957.3 million in 2023 and is poised to grow at a compound annual growth rate of 3.4% over 2024 -2030. Demand for sustainable jewelry and gender-fluid jewelry is on the rise, which is helping to propel the luxury jewelry market forward (Business insites, 2023). However jewellery manufacturing methods have not drastically changed in Thousands of years, with the earliest recorded use of investment casting dating 3700 BC (Precision Investment Castings, 2024)

This thesis explores the potential for additive manufacturing (AM) to be a manufacturing method, that could replace Investment casting for small and medium enterprises (SME's) for the luxury and precious metals in South Wales. Using primary and secondary research it will discuss the barriers the SME jewellery industry faces and will consider the opportunities that AM technology could bring to the industry and if the excitement from AM manufacturers are justified and fully costed (Mehta, 2018). In chapter two, traditional jewellery fabrication techniques such as casting will be discussed and contrasted with AM. Environmental impacts will be considered and the cost of outsourcing casting for a precious metal examined.

Chapter three examines the financial costs of supporting technology and required labour. Chapter four discusses the raw material for selective laser melting and the cost implications in addition to the reclaiming limitations of precious metal powders.

Chapter five examines the pricing structure for SLM **Put in Finance section? The** barriers to SLM manufacturing and positives that attract jewellers to this technology. It also considers other emerging SLM technologies and considers other precious metal manufacturing solutions.

Based on research conducted by the author, and secondary research, chapter six will conclude that SLM technology is not yet ready for commercial SME jewellery firms to use as their preferred manufacturing method, as the reclamation of metal eats into their profit margins and reclamation is a complex process. Furthermore, it is difficult to emulate the density and porosity of a cast part using an SLM in comparison to

traditional casting, with the result that customers would get a worse product, and jewellers would be reluctant to use this as their preferred method.

Historically 3D printing is a business-to-business (b2b) manufacturing system that primarily creates global parts for larger industrial systems, typically for the aerospace and automotive sectors (Saquib Rouf a, 2022). This research will explore the possibilities of precious metal and a straight-to-consumer business using primarily 3D printing as the manufacturing process instead of traditional jewellery manufacturing production Casting.

Arguably with this new technology and the rapid globalisation of industrial manufacturing, parts can be designed in one country, built in a second country, and shipped globally to a third country, including to the UK (Omid Fatahi Valilai, 2014). However, the impact on lead times created by shipping parts; the fluctuation in the cost of importation taxes; and the complex administration required for exporting precious metals and the extra work this entails (McBride, 2023), creates a valid argument in favour of bringing production closer to home, and for there to be UK based precious metal printing supplier.

Why Diamond Centre Wales?

Diamond Centre Wales is a jewellery firm that is an SME based in Talbot Green, South Wales. With a turnover of 1.2 million a year and 25 employees, the company is looking at how to adapt and evolve using industry 4.0 technologies. To help expand, it has applied for research grants from Innovation UK (IUK) to help see if embedding smart technology in the business would be viable and profitable but also disruptive to the jewellery industry. Because of their small premises, DCW have been outsourcing their casting of their jewellery for 45 years to Weston Beamor (WB) in Birmingham, as Wales does not have its own jewellery industrial quarter. They wanted to be self-sufficient, reduce their overhead costs and control their lead times by bringing all their manufacturing in house as well as offering their services to other jewellery firms in Wales and the rest of the UK to provide another revenue stream.

The Author was asked to lead this research project in 2021 because she had spent four years at Cookson Gold, the only other SLM precious metals facility in the UK and would be able to understand the issue that might be relevant to DCW. The author felt that this project was important as the AM technology would only work if everyone transitioned over from traditional casting.

The author spent two and a half years within DCW collecting qualitative data by interviewing a range of employees within DCW with varying roles. These roles ranged from the CEO, Director of Sales, and Workshop manager to the CAD team. A significant amount of data was produced which was used to make informed decisions about how we could embed SLM printers within DCW. Following, the strategy of the initial research

the author collected quantitative data after embedding an Alpha laser printer into DCW, which helped inform the understanding of how successful the SLM printers would be commercially. This primary research along with secondary research will be used to understand the real-life issues facing DCW and how SMEs might adopt SLM technology.

Initially, this paper will explore a straight-to-consumer business model targeting South Wales. This region has been chosen because the jewellery trade in this area has not become established in either traditional manufacturing or new technologies such as, However as a whole, Britain is known for having a thriving jewellery for traditional manufacturing (ref) 40% of the global jewellery manufacturing in the 90s was made in the UK, it does follow the trend of all industrial manufacturing, that it has rapidly decreased as consumers choose price over British made product which leads large manufacturing houses to use cheaper labour from the East to produce the jewellery. Innovative technology such as 3D printing could offer a cheaper solution to manufacturing and keep production within the UK.

Whilst the South Wales has several independent and SME's that produce jewellery for consumers, it does not have a specified location like Birmingham Jewellery quarter or London's Hatton Garden. With the absent of jewellery industry near the Diamond centre it forces them to outsource all their casting and with the added security complications of logistics, and the added lead time of shipping.

South Wales does have several established jewellery SMEs that could benefit from bringing their production line in-house. Could 3D printing offer the opportunity and. Expansion for the jewellery trade in Talbot Green? Can SMEs such as Diamond Centre Wales (DCW) afford to embed 3D printers within their business model? Is the right skillset and ambition there to take this technology forward?

Clarify the difference between business-to-business and straight-to-consumer. Lay out the pros and cons for each of these approaches, both for established traditional jewellery businesses and for individuals selling directly to customers.

This technology has not been exploited commercially straight to consumers yet and could provide a new avenue of Jewellery manufacturing for the UK and abroad.

This thesis will explore the sectional 3D printing method of Selective Laser Melting (SLM). To investigate this issue, I will explore other 3D printing disciplines to see if they offer a better solution to the issue.

This research is important, as the jewellery manufacturing trade has dwindled, retailers closed across the US by 2.8% in 2023 (DEMARCO, 2024). Fewer people train in traditional jewellery making compared to 20 years ago due to the rarity of apprenticeships available and the slow rise of wages make the career an untenable option for many people. Furthermore jewellery firms are struggling to turn a profit and

invest into their business (Jogia, 2024). This is due to the UK jewellery manufacturing trade being undercut by Primarily Asian factories that provide lower wages (REF). 3D printing could provide a manufacturing process to keep trading within the UK. However marketing reports suggest that new generations want to invest in jewellery, citing them as modern heirlooms, giving way to industry 4.0 technologies to give them immersive experiences with brands embracing new technologies such as AM (MOF, 2024)

Additive manufacturing is a new technology. To date, much of the research regarding additive manufacturing has focused on the technology, for example the design aspects of what we can build and the physics to make it possible. There is very little literature regarding the social and environmental impacts of additive manufacturing such as carbon emissions, energy consumption and the impact of this on communities. It is widely understood that casting is a dirty process that requires the constant use of a gas flame. In contrast, the general perception seems to be that additive manufacturing is a relatively clean process. However, recent research has shown that certain aspects of additive manufacturing can produce significant carbon emissions and toxic waste.

Chapter 2

Traditional Jewellery Manufacturing Methods vs Printing Methods

In this chapter I will discuss and make comparisons between traditional jewellery manufacturing and printing manufacturing, both in relation to environmental concerns and the impact of these concerns on cost and lead time and the broader pros and cons of each method. I will start with an overview of traditional casting methods and then go on to compare these with Printing methods.

Jewellery casting is a manufacturing process that has been used for over 2000 years . It allows the manufacturer to create detailed and complex metal jewellery by pouring molten metal into a mould, which is typically made from wax. This process can allow large companies to reproduce identical jewellery quickly as many pieces can be made at once. Casting takes a week lead time depending on how many orders a casting company can manage at once, for example on the run up to Christmas, casters will have a longer lead time in preparation for making stock for multiple customers.

The jewellery casting process involves several processes. it begins with begins the creation of a model, usually made from wax, which represents the final piece of jewellery. This model can be handcrafted or created using CAD software and wax 3D printing technology.

The first step is called Sprueing. The wax model is attached to a sprue, a wax rod that will create a pathway for the molten metal to flow into the mould. The wax model is then placed in a container, and a plaster-like material called "investment" is poured around

it. This investment hardens to form a mould, capturing the minute details of the wax model. The mould is then heated in a kiln, causing the wax to melt and "burn out," leaving a hollow cavity in the shape of the jewellery piece. This step is why the process is often referred to as "lost-wax casting."

The next stage involves melting the chosen precious metal in a crucible at high temperatures. The molten metal is then poured or injected into the mould cavity. Depending on the technique used, this might involve gravity, vacuum, or centrifugal force to ensure the metal fills the mould completely.

The metal is cooled naturally inside the cavity for forty-eight hours. Once cooled, the investment mould is broken away, revealing the rough metal jewellery piece. The sprue, which is now solid metal, is cut off from the piece for reuse, and the rough casting is cleaned to remove any remaining investment material, revealing the details of the design.

The final piece is inspected for any defects such as porosity or other imperfections. If it does not pass quality control a recast will be necessary. The jewellery piece undergoes various finishing processes, including filing, polishing, and sometimes additional stone setting or engraving, to achieve the final look.

Sustainability

From the steps involved with jewellery casting discussed above, there are several environmental concerns relating to Jewellery casting. It can generate enormous quantities of CO₂ and other hazardous wastes such as toxic chemicals, for example cadmium which can enter our waterways affecting ecosystems. Petroleum products are used, and metal waste is produced as a by-product of casting called 'slag', which contains potentially toxic metals and can contaminate soil and water. **Birmingham School of Jewellery Research**. These by-products require proper disposal potentially creating additional costs for the company. Inert gasses are also used to melt the metal for casting; these tend to be non-renewable gasses such as butane (Lewton-Brain, 1998).

Concerningly, there is a lack of research to ascertain the impact of exposure to atomised powders on humans involved in jewellery production in regard to respiratory problems.

What is additive manufacturing and selective laser melting?

Selective Laser Melting (SLM) is an advanced additive manufacturing process used to create highly detailed and complex metal parts directly from a digital 3D model. The

process involves using a high-powered laser to selectively melt and fuse fine metal powder, layer by layer, to build up the final object.

The following is a step-by-step breakdown of how SLM works:

1. Preparation:

- A 3D CAD model of the part is created and sliced into thin layers using specialized software.
- The appropriate metal powder (such as titanium, aluminium, stainless steel, or cobalt-chrome) is selected and prepared.

2. Layer-by-Layer Building:

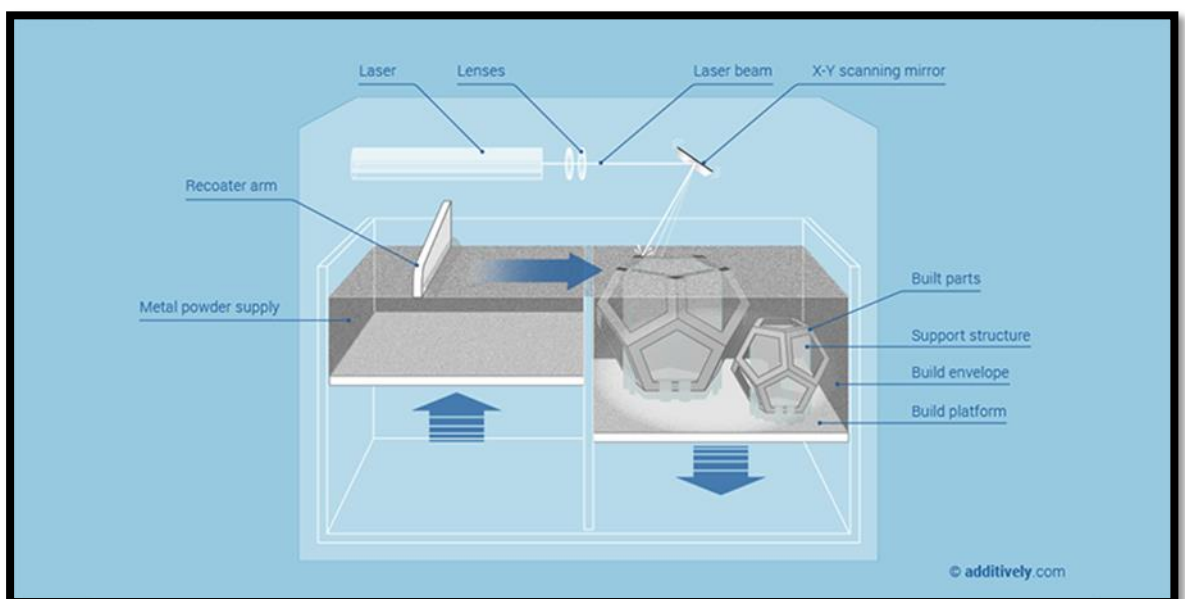
- A thin layer of metal powder is spread evenly across the build platform.
- A high-energy laser beam is directed onto the powder bed, tracing the cross-section of the part for that particular layer. The laser melts and fuses the powder particles together in the precise pattern defined by the CAD model.
- Once the layer is complete, the build platform lowers by the thickness of one layer, and another layer of powder is spread over the previous one.

3. Solidification:

- The process repeats, layer by layer, with the laser selectively melting the powder until the entire object is formed. Each layer solidifies as it cools, bonding to the layer below it.

4. Post-Processing:

After the build is complete, the part is typically embedded in the powder bed. The excess powder is removed, often by brushing or using compressed air. The part may unde



go additional post-processing steps, such as heat treatment to relieve residual stresses, machining for precision, or surface finishing.

Applications

SLM is used in various industries, including aerospace, automotive, and medical devices and tooling, where high-performance metal parts are required. It's particularly valuable for producing prototypes, custom components, and low-volume production runs.

Figure 1 Diagram of a Selective Laser Build Chamber [Ref](#)

SLM is intended only to replace the casting manufacturing parts of the jewellery cycle, and not to replace skilled jewellers or jewellery manufacturing. After discussions with jewellers as part of her research, the author realised that there is significant apprehension around AM and precious metals, with concern that it might undermine the traditionally tightknit, jewellery industry that is based around trust and contacts, and that it may even result in loss of jobs for casters.

Selective Laser Melting (SLM) has the potential to replace traditional jewellery casting in certain situations, but whether it fully replaces the method depends on various factors including the design, material, and production scale.

Material Efficiency: Strength and Durability:

There are several potential advantages of SLM over jewellery casting. First, it allows for the creation of highly intricate and complex designs that might be difficult or impossible to achieve with traditional casting methods. This is particularly useful for custom or bespoke pieces, where unique geometries are desired. SLM can rapidly produce prototypes or one-off pieces without the need for moulds, making it ideal for personalized jewellery. This can significantly speed up the design-to-production process. The SLM process is additive, meaning it only uses the materials needed to build the part, reducing waste. This is especially valuable when working with precious metals like gold or platinum. With SLM, there's no need to create moulds or patterns, which can reduce the overall time required to produce a piece of jewellery. SLM can produce parts with excellent mechanical properties comparable to, or better than, those made using conventional methods which might be beneficial for certain types of jewellery that require additional durability. Finally, the SLM process uses material efficiently, with minimal waste.

However, there are also a number of challenges and limitations to the technology. Jewellery produced by SLM often requires extensive post-processing, such as polishing, to achieve the smooth surface finishes that are typically expected in fine jewellery. This can add to the cost and time. While SLM can work with precious metals, not all alloys are suitable for the process. The selection of materials is more limited compared to traditional casting, where a wider range of alloys can be used. The initial investment in SLM equipment is high, and the per-part cost may be more expensive than casting for large production runs. For high-volume production, traditional casting might still be more cost-effective. Traditional jewellery casting involves an elevated level of craftsmanship, which can be a selling point for handmade or artisanal pieces. The "human touch" aspect might be lost with SLM, which could affect the perceived value of the jewellery. And finally, SLM is particularly beneficial for small, intricate pieces, but for larger or simpler designs, traditional casting might still be more efficient.

Commercial differences between SLM systems.

Early on in my research it became clear that I needed to consider and evaluate all the commercial systems that were ready to buy on the market in order to bring 3D printing within DCW. There were two key factors that had to be taken into consideration: budget and size of workshop space allocated to a printer. The following section discusses the pros and cons of the various printers available at the time.

Selective laser melting (SLM) technology has gained traction in the jewellery trade due to its ability to supply complex and customized designs with high precision. ProGold, a precious metal printing supplier based in Italy, employs the ReaLizer SLM system, which came onto the market around fifteen years ago, to manufacture and replace the casting method with printing. They are the longest running precious metal printing provider globally and pride themselves on their commitment to research and development. They provide a wider scope of metals than anyone else in the EU and are situated in a district in Italy that can achieve a high-level of footfall both within the Italian industrial jewellery zone, and through their excellent distribution networks across Europe. However, due to Brexit, it has made importing precious metals into the UK very expensive and unfeasible for UK jewellers (Brough, 2019). Nevertheless, this provides an opportunity for a UK based precious metal printing service to take control of that market. DCW wants to emulate the successes achieved in Italy by pro gold and take advantage of a non-competitive UK market. **These difficulties will be explained in more detail in chapter three.**

Cooksongold, a leading supplier of precious metals and jewellery-making supplies, partnering with EOS GmbH, launched their SLM-produced jewellery components in

2011 to jewellery designers and manufacturers globally. They operate SLM technology to produce intricate designs in precious metals like gold, silver, and platinum.

Cookson gold's business model involves receiving CAD files, preparing them to print, printing them and then dispatching the semi-finished precious metal goods to the client. This suits their B2B business model but, the pieces at this stage are not ready to wear and still require finishing, setting, and polishing, mirroring the processes for casting in which the component pieces emerge from the printer in a rough state and require hand finishing. However, this service has not been a success for Cooksongold, and it will be imperative for DCW to avoid emulating their mistakes and to create solutions for these barriers.

In 2011 Cooksongold attempted to commercialise 3D printing for precious metal using the EOS systems before the technology was ready. This resulted in precious metal powder being wasted and Cooksongold having to reinvest year on year, losing money.

Desktopmetal is an American-based 3D printing manufacturer which has a very successful metal printing machine with the extraordinary price tag of 1.2 million dollars which unfortunately prices out many SMEs. A well-known user of Desktop is Tiffany and co, who can afford to embed the highest spec technology into their business.

Alpha Laser introduced a new smaller SLM machine to the selective laser market in 2020 with an introductory cost of 54,000 (euros?). However, it was still very much in the research and development phase and was not ready to print with all precious metals. This required resources to be put into research and development to get the machine up to spec to be commercially exploitable.

Finally, the last system of note that could potentially use precious metal is the Exact Metal System. This system is similar in size to the alpha laser system but has not completed the research and development necessary to print.

Appendix X, presents a table showing the differences between the commercial systems in terms of laser capabilities, build platform size and dimensions of the pointing system, which helped to create an informed decision when choosing the best machine to embed into DCW.

As a result of this analysis, I chose to embed the Alpha Laser system into DCW, due to its affordability, and its compactness which would make it easy to install. In addition to these critical factors, the staff we dealt with from Alpha Lazer had a collaborative and

helpful approach and their small and simple but high spec machines were easy to clean allowing us to recoup the precious metal powder.

Machine	Price	Size	Metal capabilities	Metal reclamation	Laser
Alpha Laser	£80K**	600 × 617 × 1770 mm	Eisen-Legierungen Nickelbasis-Legierungen Cobalt-Chrom-Legierungen Edelmetalle	Unknown	Faserlaser 200 W CW, 1070 nm Fokusbereich 50 µm Scangeschwindigkeit max. 5 m/s Prozessparameter Oftener Zugriff auf alle Maschinen- und Prozessparameter
Xact Metal	£100K**	Approx. 24 x 24 x 51 in ³ - W x D x H (610 x 610 x 1,295 mm ³)	• Stainless Steel: 316L, 17-4 PH, 15-5, 400 Series • Super Alloys: 718, 625, Cobalt Chrome F75, Hastelloy® X • Tooling Steels: Maraging M300 • Bronze	Unknown	• 100W Yb fiber laser • 200W available with optional kit

Education

Commercial innovations often start within universities. For Example, Birmingham City's School of Jewellery (BCU SOJ) is globally renowned for being the best institution for the training of jewellers in the UK and has a wider variety of course, additionally they take pride in teaching innovative jewellery practices and developing Innovative techniques. Since 2008 they have partnered with Cooksongold and Electro Optical Systems GMBH (EOS) to educate students on SLM and how it can be used for manufacturing. This was a key adoption promise from Cookson who are a global bullion distributor that recognised teaching students to use the technology would create business opportunities in years to come. Following the success of this partnership other educational institutes have

adopted this technology to instruct prospective students, such as The Jewellery design Institute, based in South Africa.

The author has firsthand experience using the M080 EOS printer within BCU SOJ. failings using the machines were common and varied in their nature, for example, timings of identical print runs varied for no apparent reason. Furthermore, network issues were common and complicated network difficulties required us to EOS who provided fixes that were expensive and often unsuccessful. Because of this EOS decommissioned their M080 and M100 models resulting in these machines being unusable for students, researchers and private businesses who had been using them for small scale manufacturing runs. Educational institutes turned to larger, higher end jewellery brands to receive their updates in SLM within jewellery manufacturing.

Large jewellery houses such as Tiffany opened their own Innovation workshops where the top global jewellery metallurgists and scientists have explored innovative technology such as SLM additive manufacturing technologies for creating unique and intricate pieces that either could not be traditionally manufactured or reducing the manufacturing time, Highlighting that there is growing interest in the adoption of SLM for the jewellery sector. Tiffany has invested millions of dollars into these research programs and collaborated with Desktop Metal as their machine provider. However, results were not quick enough, and a mass defunding and reallocation of money was sent to other research projects. Which really raises the question of Is SLM technology ready to be commercialised.

Chapter 3

Financial costs of embedding an SLM into an SME

Embedding an SLM printer into an SME involves numerous costs including the SLM printers themselves which can range widely in price depending on their size, capabilities, and brand. High-quality industrial-grade SLM printers can cost anywhere from tens to hundreds of thousands of pounds (ref) Adding hidden costs such as global shipping of large-scale machinery and fragile parts, makes these machines unaffordable to smaller companies. Some printing companies offer leasing options, but even they can range from ten thousand to a hundred thousand pounds a month depending on the brand (ref). Diamond Centre Wales like many small jewellery firms, has high overheads and large disparities between monthly takings, which can cause financial difficulty and strain on their business' cash flow (ref).

The author realised that the DCW did not have enough financial capital to expand into SLM printing. As a result, it sought to ameliorate these financial difficulties by creating a

collaborative research project between DCW, The School of Jewellery, and Alpha Laser who was the machine provider. All the parties shared financial responsibility for the project and benefitted from shared intellectual property ownership (IP) that was created within the projects period. * Share what the agreement is.

Secondly, the installation and setup of printers incurs high, one-off costs to ensure it is properly calibrated and integrated into the existing infrastructure of the SME. This often includes global travel of a small team of technicians sitting within the business for a week, and training employees in the correct and complex technical skills required to run the printer. It should also be noted that to get a good grasp of these printers, new employees (especially if the employee that took on the first-hand training has left) should receive training from the printing provider to ensure the printer is not damaged and that extremely expensive precious metals are not wasted (ref).

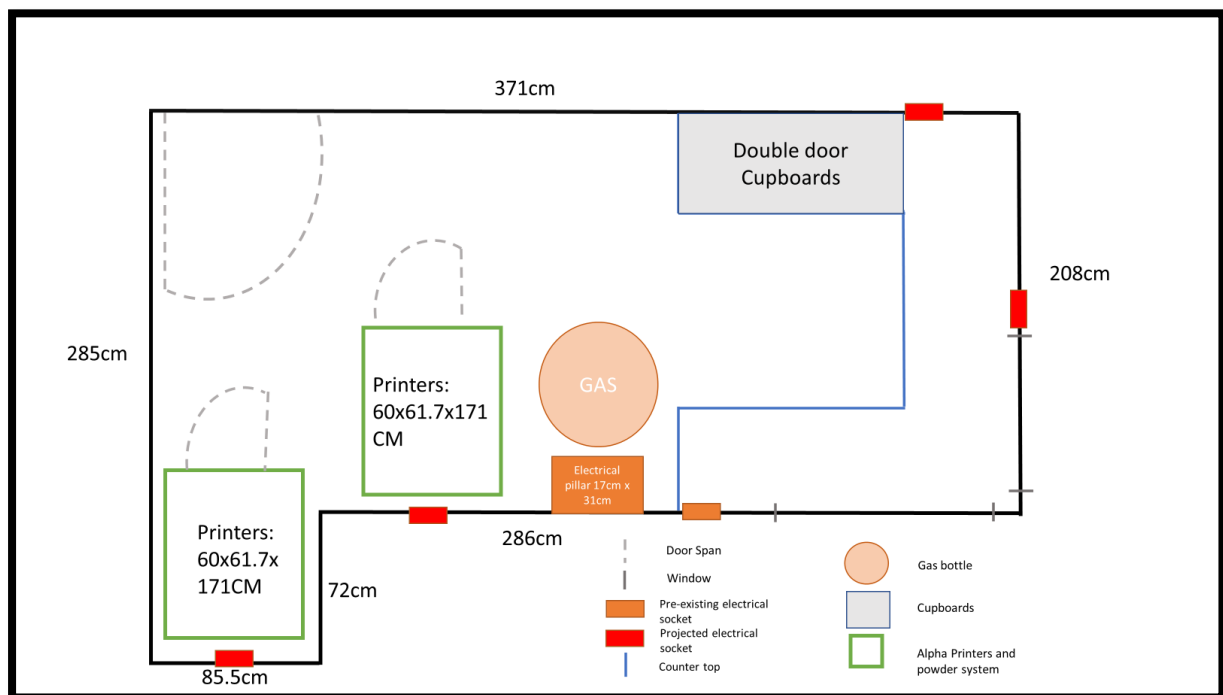
Using precious metals as the primary material is incredibly costly. The metal chosen will determine the financial costs of the initial buying of the metal. Different printers house different quantities of metal which also affects the start-up of the printer (many printers will not start if there is not a full cartridge or if 30% buffer on the volume of the build). The smallest cartridges can start at a weight of a kilo of metal but can increase to 8 kilos. To put this into perspective, 8 kilos of 18-carat yellow gold is seventy-seven thousand dollars in today's price (put int the date). Another factor to consider is that gold needs to be atomised so it can be used in the printer, thus incurring a manufacturing cost. Also to be noted is that precious atomised metal providers are far and few between meaning that there is no competitive pricing. Pricing is set by the bullion house that makes it. Thirdly, if the price of gold rises in a noticeably short space of time, the cost of running the machine can be altered immediately (think of natural disasters or wars as they have a large implication to precious metal trading prices).

SLM printers require regular maintenance to ensure they operate smoothly and produce high-quality parts. This can involve costs for spare parts, servicing, and potentially, ongoing service contracts with the manufacturer. For example, whilst embedding and using the Alpha Printer, the service team were required to fly in from Germany multiple times to fix and install the printer. However, Alpha Laser machines can be accessed, fixed, and updated remotely. These service contracts can range from £15k upwards to a hundred thousand pounds per year per machine. This is a hidden cost that is not regularly considered.

Running an SLM printer requires electricity and other utilities such as inert gas (like argon) for the printing process. The increased energy consumption and associated costs should be factored in. During the time the author was attempting to embed the machines into DCW in 2022, the UK energy and gas bills reached the highest rates in history (Huebner, et al., 2023). Alpha Laser Printers use Argon Gas, and the location set out for the printers had no gas line running through it as it would have been a large cost

to DCW. To overcome this issue, we resorted to using bottled gas, but these fluctuated in price as gas prices rose. The author then considered all amendments, and the costs associated with that for the SLM machining environment to allow safe and regular printing.

DCW needed to allocate dedicated space for the SLM printer. This required renovating the space to accommodate the machines and their needs. Firstly, flooring and walls needed to be wiped clean, facilitating the reclamation of precious metal powders. Three phase plugs with compatible electrical points had to be fitted for the polishing equipment. Air con needed to be installed to keep the room cool, but not create a breeze that would move powder around the 3D printing room.



With all this specialised equipment, trained technicians were needed to operate the machines, including a technician for the polisher and the microscope, labour costs for operating the printer, CAD technicians for the software, overhead costs, and consumables. And the post processing such as a jeweller to hand finish the pieces.

The lack of funding made

Risk Mitigation and Contingencies: It's wise to budget for unexpected expenses or challenges that may arise during the implementation and operation of the SLM printer.

The specific financial cost will vary based on the size of the SME, its existing infrastructure, the scale of operations, the chosen printer model, and various other factors. The SME needs to conduct a thorough cost analysis and feasibility study before

committing to the investment. Consulting with experts in additive manufacturing and financial advisors can also help in making informed decisions.

CASH FLOW FORE CAST

Figures to
include VAT

Figures rounded to the nearest £

[illegible]

Other office costs and laptops														
Marketing & adverts	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	21,000	5,000	5,000	5,000	60,000
Interest on loans, etc.														
Bank charges, etc														
Accountant & prof. fees	150	150	150	150	150	150	150	150	150	150	150	150	150	1,800
(Software)	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	16,800
Other Expenditure:														
Loan, HP repayment (excl.int.)														
Proprietors Drawings														
Capital Expenditure				4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	43,200

Other technology needed to support the embedding of a selective laser melting printer.

Polishers

Like traditional manufacturing, precious metals will need to be polished and post-processed after 3D printing (ref). Depending on the design and CAD file it can determine how many supports are needed to make a successful precious metal build. The more supports put on a file means that there are less likely outcomes of the build failing whilst printing. However, this can affect how the piece is finished and made ready for the consumer market. Each support leaves a witness mark (a small indentation) that needs to be filed then buffed and polished out so as not to show how the part was made, creating a mirror finish. Ideally, this means that the future supports can make an easier part to finish and quicker, thus having a positive effect on how much time is on the production line. Fewer parts less cleaning

There are automated polishers that are coming onto the market that are supporting the additive manufacturing sector. However, these are not aimed at precious metals. As these are customised, they come with a very large price tag. Alternatively, traditional jewellers that would polish precious metals could be used, but this would be very limiting to the design aspect of 3D printing due to human error and potentially removing design features. Explain a little more...

Software

Software is an integral part of the design of the printing process, from using computer-aided design [cad] to supporting and building software. These checks and quality assess the ability of the design to see if it is print worthy. But something to be noted is that the software comes at a very high price, which can often be over £60,000 per year in licencing fees. Designers and printers are at the discretion of large software providers and without this integral cog in the production line that often gets overlooked, designing for printing would not exist.

What labour is needed to support the embedding of SLM in an SME?

Integrating a Selective Laser Melting (SLM) printer into a business requires various types of skilled labour to ensure the process is efficient, safe, and productive. Here's a breakdown of the labour roles typically needed to support the embedding of an SLM printer:

Jeweller

The common misconception is with 3D printing you would reduce your workforce in regard to jewellers, this is quite the opposite, 3D printers cannot replace the work of a jeweller it will only replace the work of a caster.

Additive Manufacturing Engineer

- **Role:** This engineer is responsible for overseeing the setup, operation, and optimization of the SLM printer. They work closely with design teams to ensure that parts are designed for manufacturability using SLM and manage the overall additive manufacturing process.
- **Skills:** Deep understanding of additive manufacturing technologies, materials science, and engineering principles. Proficiency in CAD software, slicing software, and experience with SLM-specific software.

2. Design Engineer (CAD Specialist)

- **Role:** Design engineers create the 3D models that will be printed using the SLM machine. They must consider the unique aspects of SLM, such as support structures, build orientation, and post-processing needs.
- **Skills:** Expertise in 3D modelling software (e.g., SolidWorks, AutoCAD, CATIA), understanding of DfAM (Design for Additive Manufacturing) principles, and familiarity with the limitations and strengths of SLM.

3. Machine Operator/Technician

- **Role:** The machine operator is responsible for the day-to-day operation of the SLM printer. This includes setting up the machine, loading materials, monitoring the printing process, and performing routine maintenance.
- **Skills:** Technical understanding of SLM machines, hands-on experience with machinery, troubleshooting skills, and the ability to follow detailed operational procedures.

4. Material Scientist/Metallurgist

- **Role:** A material scientist or metallurgist ensures that the metal powders used in the SLM process meet the necessary specifications and that the finished parts have the desired material properties. They also work on developing or refining materials for specific applications.
- **Skills:** In-depth knowledge of metal properties, powder metallurgy, and material testing. They must also understand the behavior of materials under the SLM process, including thermal effects and microstructure development.

5. Quality Assurance/Control (QA/QC) Specialist

- **Role:** QA/QC specialists are responsible for ensuring that the printed parts meet the required quality standards. This involves conducting inspections, tests, and measurements, and working closely with engineers to address any defects or inconsistencies.
- **Skills:** Knowledge of quality control processes, familiarity with inspection tools (e.g., CMM, X-ray, CT scanning), and an understanding of industry-specific standards and certifications (e.g., ISO 9001, AS9100 for aerospace).

6. Post-Processing Technician

- **Role:** After printing, parts often require post-processing such as heat treatment, surface finishing, or machining. Post-processing technicians handle these tasks to bring the parts to their final specifications.
- **Skills:** Expertise in heat treatment processes, CNC machining, surface finishing techniques, and the ability to interpret engineering drawings for final specifications.

7. Health and Safety Officer

- **Role:** The health and safety officer ensures that the workplace complies with safety regulations and that all operations involving the SLM printer are

conducted safely. This includes managing the handling of metal powders, which can be hazardous, and ensuring proper ventilation and fire safety measures.

- **Skills:** Knowledge of health and safety regulations, risk assessment, and hazardous material handling, as well as experience in creating and enforcing safety protocols in an industrial setting.

8. Maintenance Technician

- **Role:** Maintenance technicians are responsible for the regular upkeep of the SLM printer and its associated equipment. This includes preventative maintenance, troubleshooting issues, and making repairs as needed to ensure minimal downtime.
- **Skills:** Mechanical and electrical troubleshooting, understanding of SLM machine components, and experience with industrial maintenance practices.

9. Production Manager

- **Role:** The production manager oversees the entire manufacturing process, including scheduling, resource allocation, and workflow management. They ensure that the SLM operations are integrated smoothly into the broader production environment and meet production targets.
- **Skills:** Project management, knowledge of manufacturing processes, lean manufacturing principles, and experience in managing production schedules and teams.

10. Supply Chain and Logistics Coordinator

- **Role:** This role involves managing the supply of metal powders, parts, and other materials required for SLM operations. They also coordinate the distribution of finished parts to customers or further processing stages.
- **Skills:** Supply chain management, inventory control, and coordination, with an understanding of the specific requirements for handling and transporting metal powders and 3D-printed parts.

11. IT Specialist

- **Role:** IT specialists ensure that the digital aspects of the SLM process run smoothly, including the management of 3D printing software, data security, and connectivity between different systems.
- **Skills:** Knowledge of CAD/CAM software integration, network management, cybersecurity, and experience with managing digital workflows in a manufacturing environment.

Embedding an SLM printer into a business requires a multidisciplinary team with specialized skills ranging from engineering and design to quality control, safety, and maintenance. The complexity of SLM technology means that businesses must invest in both skilled labor and ongoing training to ensure the successful integration and operation of the printer. Proper coordination between these roles is crucial to optimizing the SLM process and achieving the desired outcomes in terms of product quality, efficiency, and cost-effectiveness.

Chapter 4

How can powders be produced as raw materials for Selective laser melting?

Gas atomisation

Powders used as raw materials in selective laser melting (SLM) need to meet specific criteria to ensure high-quality printing and part properties. In this section an overview of the process of producing powders for SLM will be given.

For the research study, the materials chosen for analysis and to be used in the printer were platinum, 18 carat white, yellow, and red gold, and silver. Metals such as stainless steel, titanium, aluminium, and cobalt-chrome alloys are commonly used in SLM due to their suitability for additive manufacturing, but for the DCW study, only precious metals were investigated.

Producing high-quality metal powders for SLM requires careful control of various parameters such as atomization conditions, cooling rates, and post-processing treatments to ensure the powders meet the stringent requirements for additive manufacturing applications. At this point it might be helpful to clarify the steps taken in precious metal AM.

1. Atomization is the most common method for producing metal powders for SLM. In this process, a stream of molten metal is broken up into fine droplets using various techniques such as gas, water, and plasma atomization. Gas atomization is the most widely used method for producing metal powders for SLM due to its ability to create powders with a narrow size distribution and minimal contamination.
2. Once the metal droplets are formed, they land on a zero-degree pool of water which makes the droplets of metal diffract into atoms. The gas atomisation process can influence the size and shape of the atoms that are produced, but the SLM machine can only work with a range of atoms between 16 and 20 microns and the atoms need to be spherical.
3. The atomized metal powder is then sieved or classified to remove any oversized or undersized particles to achieve the desired particle size distribution. The particle size distribution is crucial for ensuring proper flowability and packing density during the SLM process. If the atoms are too big, they can cause blockages on the building plate which prevent the recoater from passing over and distributing powder evenly. Conversely, if the microns are too small, then the

argon gas that is flowing through the machine can push the atoms that are less than 16 microns off the plate, making the coverage of powder too thin to build with.

4. If the atoms are irregular and misshapen, they influence what the final build looks like. This will affect the surface quality of the printed parts resulting in poor surface quality of the metal, and a rough and uneven build finish. Surface treatments such as annealing, passivation, or chemical cleaning may be applied to the metal powder to improve its flowability, remove surface contaminants, or enhance its compatibility with the SLM process and improving the final finish.
5. Quality control measures are implemented throughout the powder production process to ensure consistency and quality. This may include particle size analysis, chemical composition analysis, and examination for any defects or impurities.
6. The final phase of the atomising process is packaging the metal powder in suitable containers and storing it in a controlled environment to prevent contamination with other metals or any other outside 'foreign' objects. This is to avoid degradation before it is used in the SLM process. Furthermore, security is provided through coded tags and sealed precious metal powder containers which are placed in a safe to inhibit both theft and damage enroute to the SLM company. Once Delivered, the institute in which the powders will be housed needs to consider the environment the powder will be situated in. The powder needs to be in a dry, air particle free safe that will inhibit humidity. If this is not the case, the powder absorbs moisture and can become lumpy and will then need to be dried out in a kiln, which can come at a large expense to the business due to high energy prices and the cost of purchasing further equipment. Since Brexit, the movement of precious metals has become increasingly difficult and costly. It had resulted in UK businesses only purchasing from other UK businesses. There is only one large, precious metal atomizer company in the UK, with smaller research atomising facilities that are mostly research laboratories within universities or within private pharmaceutical institutions. However, these smaller concerns would not be able to provide anywhere near the quantity of powder that is necessary for precious metal AM, resulting in the large UK provider maintaining a monopoly over the precious metal industry in the UK and controlling the. This monopoly has an adverse impact on AM profit margins in the UK. issue is a major factor in profit margins and creating a pricing structure that can compete with traditional manufacturing methods such as casting.

In the next section I will discuss the financial implications of purchasing precious metal powders for DCW.

Plasma atomisation

Auditing and storing precious metal powders

Before looking at the financial implications of purchasing precious metal powders, it is helpful to understand the reasons for the high costs relating to the storage of precious metals and maintaining the integrity and composition of the metals, in other words, keeping them viable for printing.

SLM 3D printers create parameters for each metal composition, so that there is a different set of parameters for each metal. If there is a slight change or discrepancy in the metal, the metals will not print.

As we know, precious metals are made up of different elements outside of gold. For example, 18 carat yellow gold is made up of 75% AU gold, 2 % copper, 2 % steel 5% carbon and 7% Nickel

For the parameters to be created, cubes of the desired metal are printed (not always successfully) with different variables introduced such as laser speed, heat deposition, and laser power. Once created, the cubes are sent to a metallurgy Lab and tested for density and surface roughness. When the results are analysed, the parameters for laser speed, laser powder and heat deposition are then altered,

and the cycle of tests is repeated until the cubes reach the optimal density and surface finish, similar or better even than a traditionally cast piece of metal. The improved cubes enable commercially viable licences to be created that can create jewellery products for consumers. However, for the parameters to work, it is imperative that there is a continuity (consistency?) with the metal as any contamination will mean that the parameters will not produce an optimal piece and will fail quality assurance checks. At the DCW, we quickly learnt that contamination of the powdered metals could easily take place. To prevent this, regular metallurgist testing was necessary. Unfortunately, this was an expense that DCW could not accommodate. As a result, we were reliant on universities to undertake the metallurgy testing on our behalf. This was a slow process that contributed to author's research running out of time.

The graph in figure 1, shows the different metals that were present in a gram of white gold taken from the large batch that diamond centre Wales used to create parameters. The author sought to clarify why the metal was not behaving as expected and used metal compound analysis machines at Aberystwyth university to get a full profile of the metal composition. As you can see there are metals that we would expect to be in the metal batch including palladium, gold, iron, silver, copper and nickel. However, there

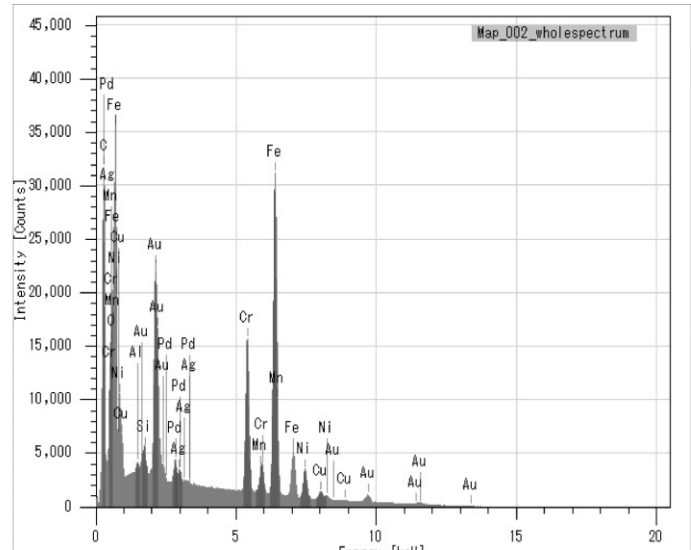


Figure1 Metallurgy composition analysis (Paparozzi-Shipman, 2023)

are also metals that we would not expect to be within the sample search such as magnesium, chromium and iron. The reason that the last two metals can infringe on parameter development is because they will affect the chemical compound and melting points of white gold. Furthermore, the reflectivity of magnesium can have a disastrous effect on the laser itself when it is pointed at the metal. It will create homogeneous melting pools within the metal, due to the higher temperature of the metal batch due to the magnesium content.

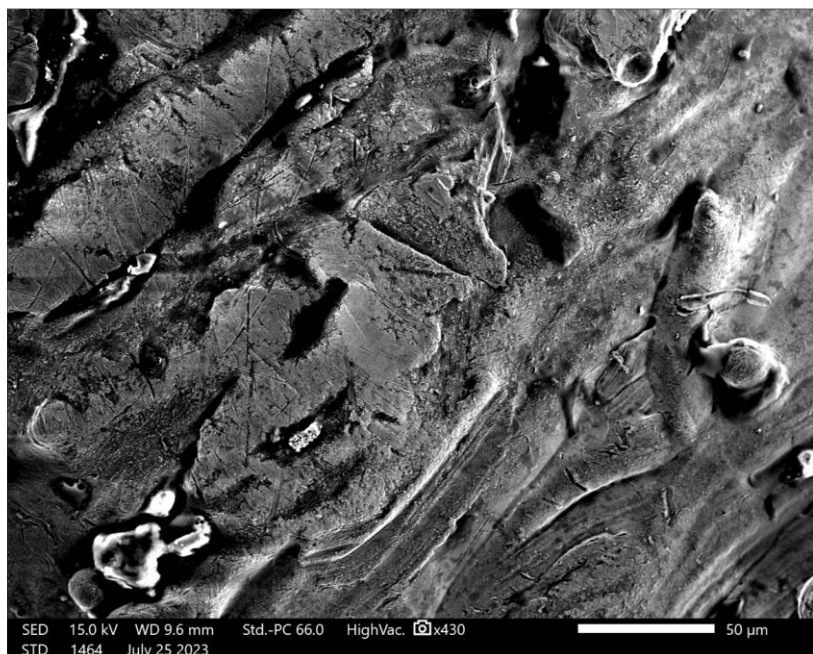
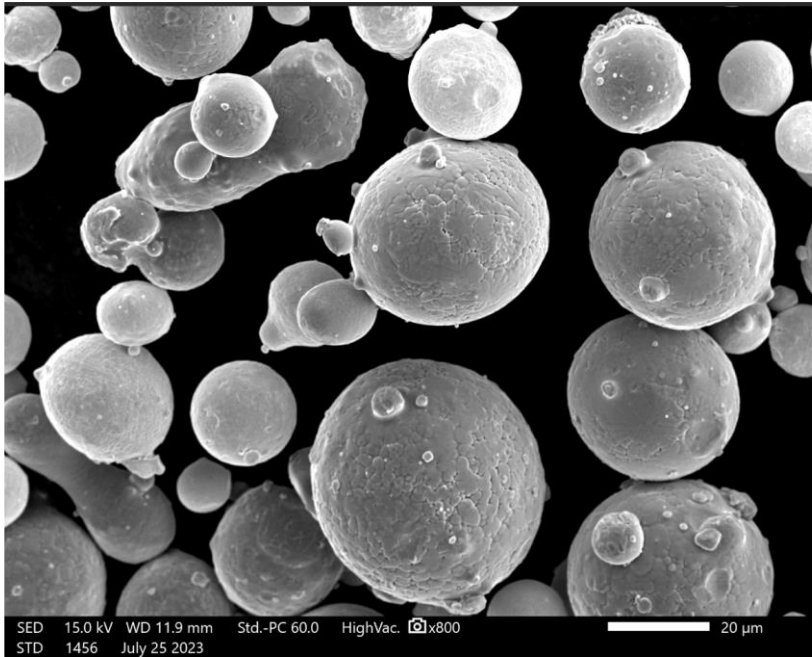
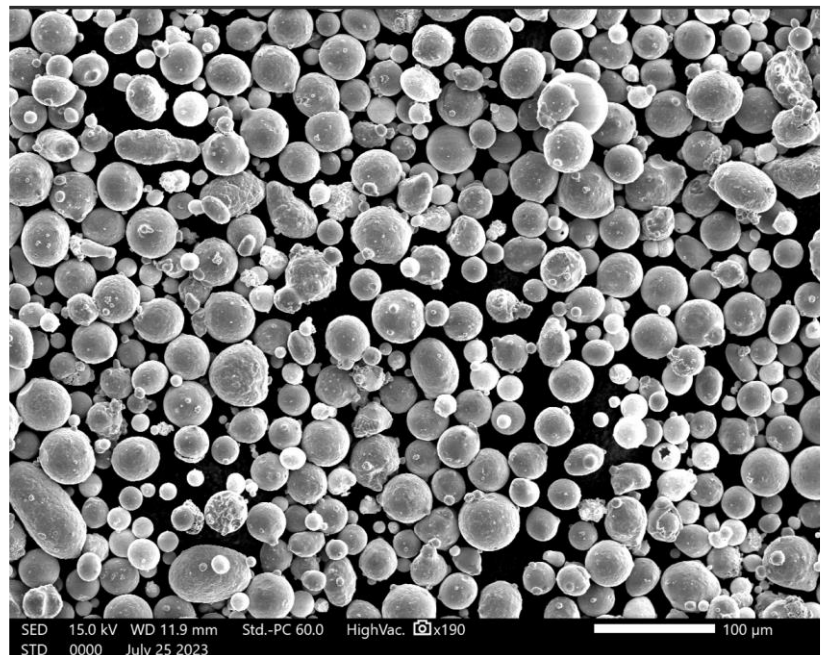


Figure 2 surface under a microscope of white gold (Paparozzi-Shipman, 2023)

Looking at the microscope photo of figure 3, you can see the surface area of a white gold metal sample. Ideally the surface of the metal will present a smooth Matte appearance which would make easier to Polish after the post processing. If the surface area is rough, it means that the post processing Polish would require to take off more metal to create a Smooth and aesthetically pleasing appearance.

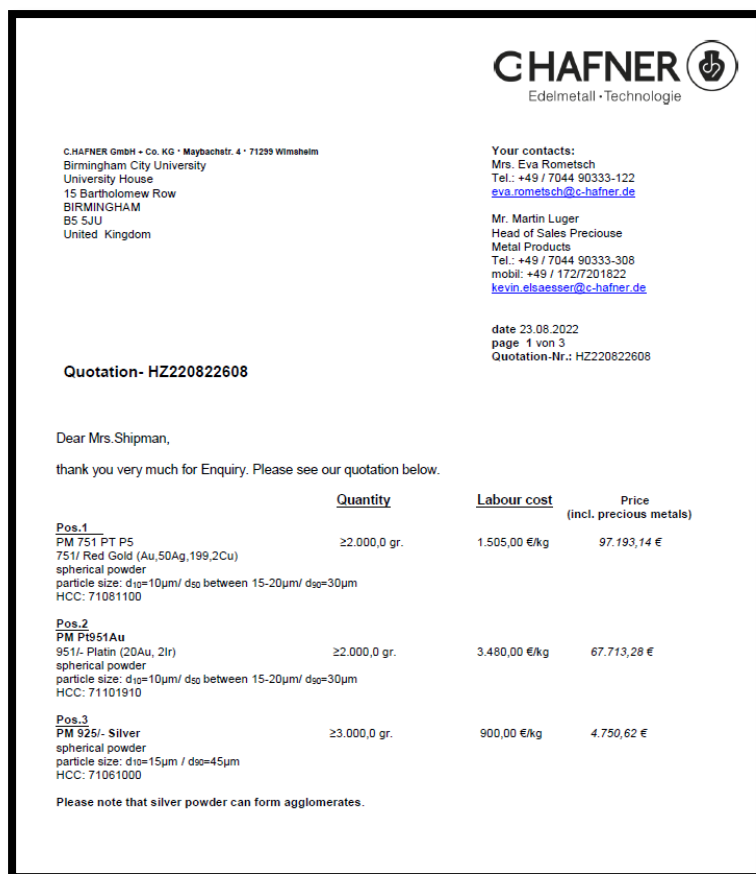


When looking atomize metals under a microscope the desired atom structure should be spherical and similar sized atoms. This helps for powder distribution when pushing across the build plate in a 3D printer, if the atoms are too small, they will move when the gas distribution is turned on, if the atoms are irregular and Oval in shape they can cause irregular surface finishes and also will not move across the build plate smoothly resulting in blockages.



What are the costs and implications of using atomised powders?

Costing of powders



Diamond Centre Wales looked at European markets for a more competitive pricing,

What are the reclaiming limitations of SLM and how does it impact the cost of printing?

Reclamation comes at a cost

Reclamation is a massive side income for jewellers. At least annually jewellers will deep clean or have an external company come and deep clean their working spaces for them. Powdered precious metals tend to escape into the environment. Just a gentle current of air will lift the powder and disperse it widely in the environment. The aim of the reclamation process is to recover this powdered metal from a variety of sites that tend to accumulate the powder, such as sinks and toilets. The process may also include taking up floorboards and incinerating them to leave behind the precious metal deposits, then replacing them. It's a large-scale sub business that has seen companies returned with hundreds of thousands of pounds depending on the scale of their organisations.

Tax deductible because it is waste?

This also needs to be translated over to additive manufacturing practices. Typically, AM uses Steel, aluminium and titanium which are low-cost materials. Because of this it is normal to be complacent with the AM materials and not reclaim them. But this practice

is not viable for precious metal AM. It cuts into companies' profit margins. As discussed previously, atomised precious metals are an incredibly expensive material to work with, and as such, need care and consideration when using. This also needs to be the mindset of the technicians. Adaptations to workflow need to be stringent and followed closely. Every gram needs to be accounted for.

Moreover, the health aspects of handling powdered metals need to be considered. The wearing of masks is obligatory to prevent inhalation of the powdered metal. There are two types of masks: one has a standard paper filter to reduce inhalation of powder, and the other filters out the air the technician breathes. In addition, clothes worn by technicians need to be washed, ideally in industrial launderettes with filters. This process can also lead to reclamation of powdered metal, but this metal can only be considered as scrap metal. It can be sold back to scrap metal companies such as Master Melt, but at a lower price, and they also take a percentage of the metal away with them. However, powders left in the machine are in a controlled environment, and if handled correctly these can be used again for future builds.

Powders used should be sieved after each build to separate the larger and unusable particles that form within builds from powder that can be used again. It is imperative that larger atoms are removed as they can cause blockages and subsequently damage to the recoater of a machine and create blockages.

Wooden filters

Selective laser melting machines typically have aluminium filters. These are exceedingly difficult to extract precious metals from. One adaptation that can be made to an SLM printer to make it more efficient is to use wooden filters. The Diamond Centre worked with Alpha Lazer to create this adaptation so that it was easier to track metal powders and reclaim metal by burning the wooden filters and **reclaiming the waste**. The filters are weighed to ascertain how much metal has been trapped in them. The waste is then sold to scrap metal merchants.

CO2 impact on burning rubbish.

SLM claims to be a more environmentally sustainable Manufacturing process than traditional fabrication methods, However, what is the CO2 implication of burning waste? This is a Hidden environmental impact that is not considered, when talking about selective laser melting's Sustainability Impact.

Auditing for metal

Chapter 5

What is SLM's pricing structure, and how does it compare to casting?

Before investing in machinery, it is important to show how competitive the pricing is between 3d printing and casting, and what commercial viability there is for 3D printing, especially in comparison to traditional manufacturing methods such as casting.

While sustainability will be the major reason that people want to convert to 3D printing (slurry) Unless the price of the product is the same or cheaper, a large proportion of businesses will not convert over to the new manufacturing methods. ***** independent research regarding customers***** This is because a slight rise in manufacturing eats into a company's margins (by what percentage???). Most businesses put a 300% mark-up on manufacturing. Ideally, 3D printing would offer a cheaper, more sustainable and a better product for its customers.

At this point, it might be helpful to examine independent research carried out by the author that indicates what the projected trade prices for 3D printing is in comparison to the already functioning casting. *****Insert casting and printing pricing structure*****

Example Pricing Structure:

To illustrate, if a jeweller is casting a gold ring, the pricing might look like this:

- **Material Costs:** 10 grams of 18k gold at £60/gram = £600
- **Labor Costs:** Design and casting labor = £200
- **Overhead Costs:** Equipment and workshop overheads = £100
- **Finishing Costs:** Polishing and stone setting = £50
- **Markups:** 50% markup on total cost = £475
- **Total Price:** £600 (material) + £200 (labor) + £100 (overhead) + £50 (finishing) + £475 (markup) = **£1,425**

This is a simplified example, and actual pricing can vary based on market conditions, the jeweller's location, the complexity of the piece, and other factors.

The pricing structure for precious metal casting is a combination of material costs (dominated by the precious metal used), labor, overhead, and profit margins. Each of these factors contributes to the final price of the jewelry piece. Understanding this structure is crucial for both jewelers in setting prices and customers in understanding the cost of custom-made jewelry.

Furthermore, the difference in quality between casting and printing varies Between metal and different carrots. For example, Platinum works incredibly well. With selective laser melting. And in comparison. Red gold. Which is high end copper. Is still in a research and development phase with most selective laser melting machines and is not ready for the commercial market.

- Casting pricing structure
- Compare to the pricing structure already written – upload document
- B2B value-led, however, we take pride in quality and price. Aiming for the price point to be competitive to a cast part if not slightly undercut.
-

Barriers to SLM Manufacturing

- Access to CAD/ cost of licence and laptop

The startup. And annual licencing costs of embedding technology. And. Software can be a hidden cost that people don't consider When adopting additive manufacturing. Licences can range Anywhere upwards from 12K to 25K per year depending on what software. This is a massive adoption and ongoing cost that needs to be factored into SLM pricing structures.

- Cad training/ education

CAD can be a difficult Skill for long term jewellers to adopt, it requires months (if not years to master this skill). They can hire or outsource this job however this again eats into manufacturing costs. This barrier can be very off-putting for jewellers to adopt as wages are incredibly expensive.

- Cost of CAD designer

What are the positives that attract jewellers to this new technology?

- Parts have a lower porosity and higher density rate than traditional cast metal, meaning clients get a better-quality product.
- Post-processing of parts is on average 2/3rds quicker to polish and finish due to lack of porosity, so clients can produce more time and reduce labour costs.
- Possible design capabilities that our competitors and casters cannot achieve, such as;
 - **Hollow or light weighted parts – Meaning that clients could lower their prices whilst offering their customers luxury jewellery**
 - **Articulated parts – moving parts that would traditionally need to be assembled in many parts and be very labour intensive, reduces labour costs as this can be built as one part on the printer.**
 - **High customisation, parts can be recreated easily but have customisation to still be bespoke to customer**

- **Shorter lead times** – We can print 1-60 parts in a few hours with potential 24-hour manufacturing capabilities.
- **High resolution parts** – parts can achieve a very high resolution and lets designers go into detail down to 100 microns
- A website with a library and customisable jewellery feature so customers can quickly add STL's and design jewellery on the site.
- Businesses can create stock with our manufacturing, when their stocks become low, they automatically generate an order to replenish their stock, offering a solution to stock takes to companies.
- This offers a sustainable manufacturing method in compared to casting in which the carbon output is high.

What other emerging AM technologies could offer a precious metal manufacturing solution?

- Ecam – Fabric8

Machine	Price	size	Other machinery	Metal reclamation	Metal capabilities
Holo	Unknown	Unknown	Yes: Depowdering machine Furnace	Unknown	Silver Would require parameter development
Desktop	£500-£750K	1,770 x 2,007 x 1,150 mm (70 x 79 x 45 in)	Yes: cross powder Furnace	Unknown	Silver Would require parameter development

Chapter 6

Conclusion

the technology works however the cost per ring is not competitively priced

References

Cooksongold, 2024. *World Leading Experts in Precious Metal Additive Manufacturing*.

[Online]

Available at: <https://www.cooksongold-am.com/>

[Accessed 12 04 2024].

[Selective laser melting \(SLM\) of gold \(Au\) - University of Wales Trinity Saint David \(uwtsd.ac.uk\)](#)

[Deepening the synergistic role of additive manufacturing and computational strategies in jewellery - University of Wales Trinity Saint David \(uwtsd.ac.uk\)](#)

Xiong, W., Hao, L., Li, Y., Tang, D., Cui, Q., Feng, Z., & Yan, C. (2019). Effect of selective laser melting parameters on morphology, microstructure, densification and mechanical properties of supersaturated silver alloy. *Materials & Design*, 170, 107697-.

<https://doi.org/10.1016/j.matdes.2019.107697>

Xiong, W., Hao, L., Li, Y., Tang, D., Cui, Q., Feng, Z., & Yan, C. (2019). Effect of selective laser melting parameters on morphology, microstructure, densification and mechanical properties of supersaturated silver alloy. *Materials & Design*, 170, 107697-.

<https://doi.org/10.1016/j.matdes.2019.107697>

Khan, M., & Dickens, P. (2012). Selective laser melting (SLM) of gold (Au). *Rapid Prototyping Journal*, 18(1), 81–94. <https://doi.org/10.1108/13552541211193520>

Sohrabi, N., Jhabvala, J., Kurtuldu, G., Frison, R., Parrilli, A., Stoica, M., Neels, A., Löffler, J. F., & Logé, R. E. (2021). Additive manufacturing of a precious bulk metallic glass.

Applied Materials Today, 24, 101080-. <https://doi.org/10.1016/j.apmt.2021.101080>

Anonymous2018, Jun 08. United States: Global Precious Metals Additive Manufacturing Markets Report 2018 - 10 Year Projections to 2028 for Gold and Gold Alloys, Silver, Platinum and Others. *Asia News Monitor*.

https://additivemanufacturinguk.org.uk/wp-content/uploads/2023/02/AM-UK_Strategy_Publication_Amends_Novermber_Digital.pdf

<https://southeast.newschannelnebraska.com/story/49881173/precious-metals-in-additive-manufacturing-market-investigate-market-growth-2023-2031>

https://raeng.org.uk/media/ak3htcyo/additive_manufacturing.pdf

<https://www.maximizemarketresearch.com/market-report/global-metal-powders-for-additive-manufacturing-market/63568/>

<https://www.maximizemarketresearch.com/market-report/global-metal-powders-for-additive-manufacturing-market/63568/>

Appendix

Interview with Siantel James Diector of DCW

- **What does the average spend per engagement ring sold per customer?**
£3500 per engagement ring – Platinum and diamond are the most popular.
- **What is the average spend per non-wedding jewellery per customer?**
£1000
- **What is the percentage of Wedding ring to non-wedding ring jewellery sold?**
3:1 wedding ratio – Wedding jewellery is bigger than engagement rings
- What do we need to be bringing in a week to cover overheads?
Ask Kelvin
- What are the quarterly and yearly targets for DCW regarding revenue?
18 Carat Yellow, 18 carat Rose, 9 Carat White
- What is the percentage of precious metal market share for DCW (I know platinum is the most popular but what are the % of other metals)
18 Carat Yellow, 18 carat Rose, 9 Carat White
- How much do we spend per month with Weston Beamor?
Otters
- How much do we sell through the website/ social media?
Data from Matt.

- How many customers do we see a week?
30 Customers a week
- How many of those customers convert to an order?
85% conversion rate to order (not all, customers just want 1 thing – more like 45 jobs a week)
This doesn't include the shop – repairs, stock Jewellery.
Re-makes and redesigns are more popular.
Cluster Rings

- Which are the most popular wedding/engagement styles?
 1. Halos
 2. Cluster rings
 3. Oval diamond
 4. Diamond shoulders
- Which are the most popular non-wedding style jewellery ordered?
 1. Pendants (hearts and solitaires)
 2. Eternity rings (most popular)
- Which Collection has been the most popular?
 1. Enchanted
 2. Spring dawn

We do monthly collection (look books)

- What are the predictions of jewellery trends we think the DCW will see in the next year?
 1. Modular, interchangeable jewellery
 2. Hoops and studs
- How does DCW calculate their pricing?
 1. Metal
 2. Stones
 3. Labour
 4. Profit margin per category
- How much does one unit of jewellery cost from Weston Beamor
Platinum cast: £200 (per engagement ring per 5g)
- What density and porosity would be expected from a cast part?
- What should be the expected surface roughness for casting?

- How much time is allocated for polishing per part (let's base this on a ring)
- Who does DCW look at for local competition?
- Northern Star – Matt -Penarth and Swansea
- Who does DCW look at for national competition?
- Who does DCW look to as inspiration for branding/ marketing/ design styles/ customer service?

Interview with Kelvin James CEO of DCW

Section One

Products and services

Bureau service

1.1 What are you going to sell?

A product

A service

Both

1.2 Describe the basic product/service you are going to sell:

- Bring manufacturing in house by imbedding a SLM/ Binder jetting/ Pure Forming 3D printer to support current sales.
- Producing innovative designs that differs us from our competitors.

1.3 Describe the different types of product/service you are going to be selling:

- Traditional wedding jewellery
- Non wedding jewellery sales

1.4 If you are not going to sell all your products/services at the start of your business, explain why not and when you will start selling them:

1.5 What does the Time line for your Project? Please add more rows as appropriate.

Year	
1	40% of current sales figures to be made in house
2	75% of current sales figures to be made in house. Support launch of Sister brand of non-wedding jewellery
3	85% of current sales figures to be made in house Support of Sister brand of non-wedding jewellery and build on 10% of last year
4	100% of current sales figures to be made in house Support of Sister brand of non-wedding jewellery and build on 10% of last year
5	100% of current sales figures to be made in house Support of Sister brand of non-wedding jewellery and build on 10% of last year

Section Two

The market

2.1 Are your customers:

Individuals
Businesses
Both

2.2 Describe your typical customer:

- **Wedding based customers 25-40**
- **Non wedding jewellery 25 to 34**

“Further studies reveal that millennials spend more on fine jewellery than any other age group, and in the last year alone, individuals aged between 25 – 34 years spent as much as 28% more of their average household income on fine jewellery. The studies further revealed that these millennials aren’t the only youngsters that have changed their purchase habits, with consumers below 25 years increasing their expenditure on jewellery by 100% between 2003 –2013.”

2.3 Where are your customers based?

- Wedding sales, south Wales
- Non wedding sales, global

2.4 What prompts your customers to buy your product/service?

- Wedding sales, upcoming nuptials.
- Non wedding sales, trends, Identity, experience, quality.

2.5 What factors help your customers choose which business to buy from?

- Dynamic designs that offer a cheaper way to access fine jewellery.

2.6 Have you sold products/services to customers already?

Yes

No

If you answered “yes”, give details:

2.7 Have you got customers waiting to buy your product/service?

Yes

No

If you answered “yes”, give details:

2.8 Additional information:

Section Three

Market research

3.1 Key findings from desk research:

Theses below websites are luxury and precious metal bureau services

- [Development of an Additive Layer Manufac.pdf](#)
- [Services | Harrods.com](#)
- [Shapeways: Gold](#)

Here is the total spend for WB in each year:

- Jan – Dec 2018 - £21575.31 net
- Jan – Dec 2019 - £248274.43 net
- Jan – Dec 2020 - £189719.95 net

- Jan – Aug 2021 - £123076.26 net

Bringing all manufacturing in house will reduce lead times and manufacturing costs over time.

3.2 Key findings from field research – customer questionnaires:

N/A

3.3 Key findings from field research – test trading:

N/A

3.4 Additional information:

Section Four

Marketing strategy

Please circle which mediums of promotion you will use:

- Website (information only)
- Website (for e-commerce)
- Advertising (online)
- Advertising (print, radio, TV)
- Search engine marketing
- Social media
- Retail outlets
- Telesales
- Referrals
- Leaflets
- Events and exhibitions
- PR
- Other

Section Five

5.1 How much investment will you need from DCW? Why?

- Cost per machine, metal investment and refining.
- 250k to 300K

5.2 Have you looked and/ or got a grant?

- Fintech
- AMventures

5.3 How many staff are needed for this project and who?

5.4 How many staff will be needed for this project year on year? Outline the key staff roles within your business (e.g. job title, responsibilities, key skills):

Year	Staff numbers and Role
1	Maria (PM), 1 machine tech, 1 researcher
2	Maria (PM), 1 machine tech, 1 researcher, 1 CAD Tech
3	Maria (PM), 3 machine tech, 1 researcher, 2 CAD tech, 1 sales rep
4	Maria (PM), 3 machine tech, 1 researcher, 2 CAD tech, 1 sales rep and 1 Administrator
5	Maria (PM), 3 machine tech, 2 researchers, 2 CAD tech, 1 sales rep and 1 Administrator

5.5 Can your business be operated remotely?

- Administrator and CAD techs can work remotely
- Sales rep will be travelling and working remotely.