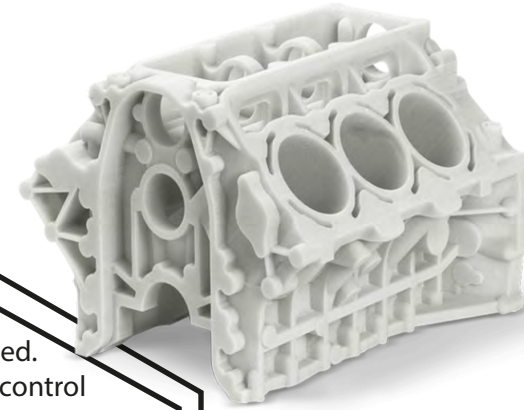
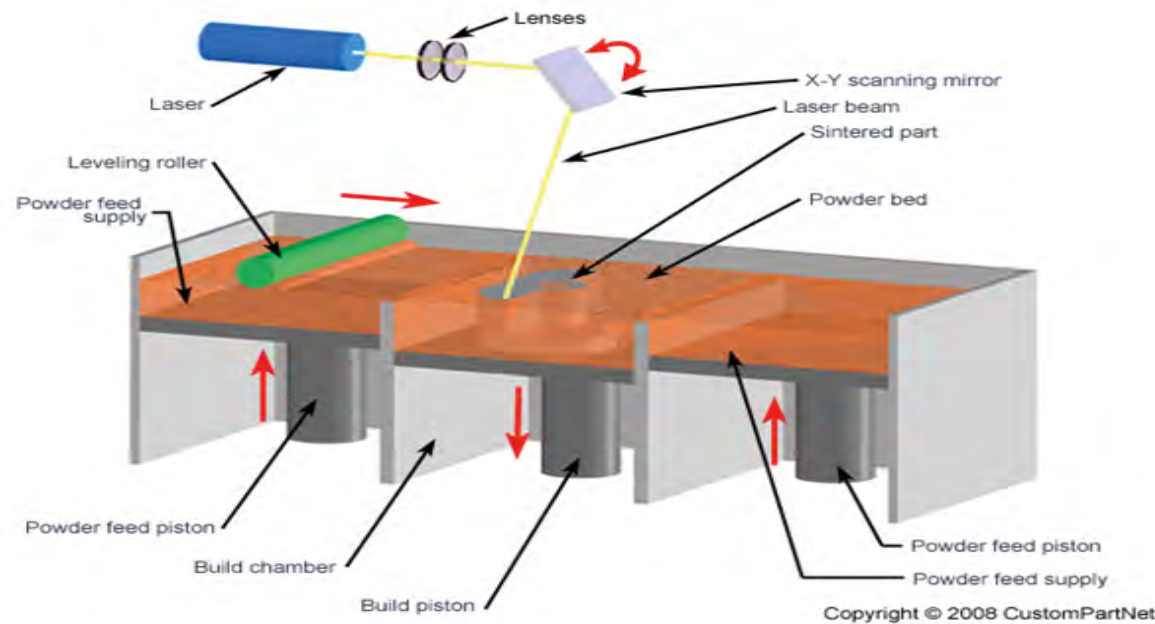


Additive manufacturing SLS (selective laser sintering)

Additive manufacturing refers to 3d printing a process that involves creating three dimensional objects in certain materials by binding layer after layer on top of each other which is controlled by a CAD programme. The SLS instead uses a laser to heat up and bind a powdered material together which can create very complex geometric shapes that are usually rather difficult or impossible to do with other types of machinery.



The SLS machinery works by first installing a CAD design into the printer which is scanned. Next the printer emits a laser onto a scanning mirror that projects the laser beam onto the powder bed. The powder bed is held up by pistons that control the height and the amount of powder being put into the Chamber. The piston also heats the powder to just below its melting point allowing the beam to quickly join the powder particles together to make a solid form. Once the layer of powder is scanned and cross sectioned by the laser beam the piston lowers down slightly, allowing a delivery system to apply another layer of powder. Not all the powder in the chamber is bonded together by the laser beam which acts as a structure which gives support to the object that is being made (this is another reason why there is such an interest in SLS because support structures don't need to be included in the cad design). Once the part is made the chamber is left to cool down naturally and then is moved to a cleaning station where the part is removed from the powder.

At the moment SLS is mainly used in low /batch volume production and prototype manufacturing. Since there is no need for tooling you can go straight in to production after the prototyping is complete due to how you can only need a CAD design to start production. The benefit of using SLS for prototyping is that it reduces the time it takes for a product to reach the market.

The cost of SLS prototyping is based on how long it takes for the part build time. Single part manufacturing is not recommended since if multiple parts are printed all together it can reduce cost.



The overall time it takes to produce a part is dependent on the volume of the part. This is due to the thickness of each layer in the part. For example the SLS machine can produce up to 2mm to 3mm per hour in 0.1mm layers. One drawback that is relevant to the overall speed is that parts have to be left to cool which can increase cycle time by 50%. (Thompson, 2007 p. 236). Since you are able to construct multiple parts in the building chamber this decreases actual prototype constructing time since you save a lot of time in the development stage.

SLS offers a number of different material with the majority being polyamide based. Polyamides are synthetic thermoplastic polymers, more commonly known as nylons. The table below summarises the most common materials that are printed via SLS. (www.3dhubs.com)

Material	PA12	PEBA(TPA)	ALUMIDE	PA11	PEEK
Properties	Good dimensional stability, good wear resistance and high chemical resistance	Rubber-like, strong yet flexible material.	High stiffness and good post-processing abilities.	High impact resistance and environmentally friendly.	Excellent mechanical properties, high temp resistance



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Additive manufacturing SLS (selective laser sintering)

Additive manufacturing refers to 3d printing a process that involves creating three dimensional objects in certain materials by binding layer after layer on top of each other which is controlled by a CAD programme. These objects that are processed are used in many fields of design and manufacturing ranging from food packaging to aerospace parts. The usage of additive manufacturing has grown over the years which has able it to become more commercial since the cost of buying a 3d printer has dropped dramatically since the 1980s allowing small and large business to buy them at reasonable prices.

This has abled the growth of 3d printing usage in the market since originally there was a problem with how it was high costing to run and would only produce low amounts of production meaning that it was most suited to prototyping. This has obviously changed since 3d printing has expanded too many forms such as SLS (selective laser sintering).

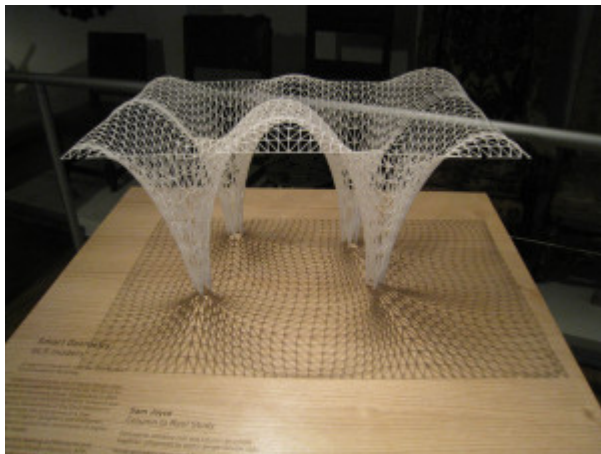
The way in which SLS functions differently to other 3dprinting machinery is that instead of printing layers on top of each other, the SLS instead uses a laser to heat up and bind a powdered material together which can create very complex geometric shapes that are usually rather difficult or impossible to do with other types of machinery. Although SLS printer are more expensive than other 3d printers to buy due to its high powered laser beam, gas chamber and pistons meaning that it can be hard to engineer and fix if not used properly. This means that unlike other printers that are becoming more and more commercial the SLS printer is not at that stage yet but this doesn't stop many companies investing and using them since producing parts is cheaper than using other 3d printing methods which makes it ideal for batch production.

Comparison of SLS Systems

	Benchtop SLS	Industrial SLS
Price	Starting at \$10,000	\$200,000-\$1,000,000+
Print Volume	Up to 165 x 165 x 320 mm	Up to 550 x 550 x 750 mm
Pros	Affordable Simplified workflow Low maintenance Small footprint	Large build volume High production rate Extensive material options
Cons	Medium build volume	Expensive machinery Large footprint High maintenance Operator required

The comparison is based on the Formlabs Fuse 1 benchtop SLS system and industrial SLS systems by EOS and 3D Systems.

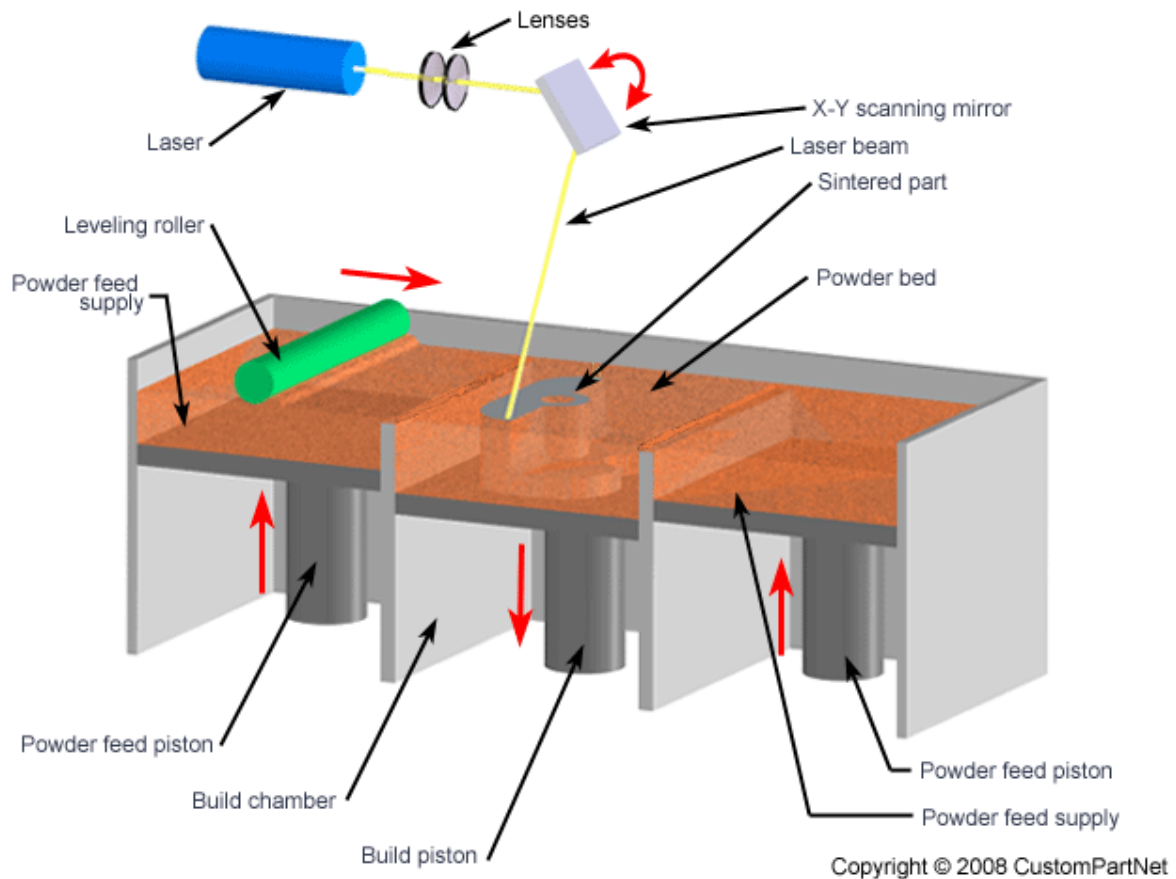
The main reason for there being such an interest in SLS especially is because it is able to use more materials than other 3d printers and is able to produce prototypes that can interlock, move and another advantage is that multiple parts can be produced together and not at separate times making it beneficial when it comes to fast prototyping meaning less time is spent which means saving money. These materials include metals and glass which are made into powders which do need to be treated with care which includes labour cost but unlike other printers there is less material costing involved due to how the excess powder that is left in the chamber of the printer can be reused.



comes out of chamber as it is without any supports attached to it.

The SLS machinery works by first installing a CAD design into the printer which is scanned but the CAD designs can only come from software that are compactable with the printer. These software's include Craft ware, MeshLab, fusion 360 and etc. Next the printer emits a laser onto a scanning mirror that projects the laser beam onto the powder bed. The powder bed is held up by pistons that control the height and the amount of powder being put into the chamber. The piston also heats the powder to just below its melting point allowing the beam to quickly join the powder particles together to make a solid form. Once the layer of powder is scanned and cross sectioned by the laser beam the piston lowers down slightly, allowing a delivery system to apply another layer of powder. Its common in these machine to have a roller that goes over the powder layer to make sure it becomes levelled/flat and to get rid of any excess powder which goes into a separate chamber that is not scanned by the laser or heated so that it can be re used. Not all the powder in the chamber is bonded together by the laser beam which therefore acts as a sort of cake structure which gives support to the object that is being made(this is another reason why there is such an interest in SLS because support structures don't need to be included in the cad design). Once the part is made the chamber is left to cool down naturally and then is moved to a cleaning station where the part is removed from the powder. After the part is removed the surface of the part needs to be post processed

to become smoother.



Materials

SLS offers a number of different material with the majority being polyamide based. Polyamides are synthetic thermoplastic polymers, more commonly known as nylons. The table below summarises the most common materials that are printed via SLS.

Material	Properties
PA12	Mechanical properties comparable to injection moulded polyamide, good dimensional stability, good wear resistance and high chemical resistance
PEBA (TPA)	Rubber-like, strong yet flexible material.
Alumide (Aluminium filled polyamide)	High stiffness and good post-processing abilities.

Material	Properties
Carbon filled polyamide	High stiffness and strength.
Glass filled polyamide	High stiffness and wear resistance.
PA11	High impact resistance and elongation at break, environmentally friendly.
PEEK	Excellent mechanical properties, high temperature resistance, potential for biocompatibility and sterilizability.

Pa plastics are the most commonly associated material with sls printing the link below from 3dsystems shows more information on this material.

[Pa/3dsystems](#)

Designing for SLS

Like all manufacturing techniques there are several design recommendations that exist to improve the quality, surface finish and functionality of SLS parts. One of the most advantageous characteristics of designing and printing parts using SLS is that there is no need for support structures. The un sintered powder surrounding the part removes the need for support allowing highly complex and intricate designs to be printed.

Print features

General guidelines for designing SLS parts are:

Feature	Description
	Wall thickness - The minimum wall thickness to ensure a successful 3D print varies between 0.7 mm (for PA12) up to 2.0 mm (for carbon filled polyamide).

Feature	Description
	Hole size - All holes should be larger than 1.5 mm diameter.
	Escape holes - To save weight (and sometimes costs) SLS parts are printed hollow. To remove unsintered powder after production escape holes must be included. Escape holes must be a minimum of 3.5 mm diameter.
	Feature size (pins, protruding features etc.) - A minimum size of 0.8 mm is recommended.
	Embossed and engraved details - To ensure small details are visible the following rules apply: Minimum depth of engraving 1 mm Minimum height of embossing 1 mm
	Text - To ensure readability of text the following rules apply: Minimum font height of 2 mm (font size 14) suitable for every direction Sans serif font is recommended for readability
	Tolerances - Typical tolerances for SLS parts are ± 0.3 mm or ± 0.05 mm/mm, whichever is greater.

(<https://www.3dhubs.com/knowledge-base/how-design-parts-sls-3d-printing#post-processing>) data sheets above

Speed

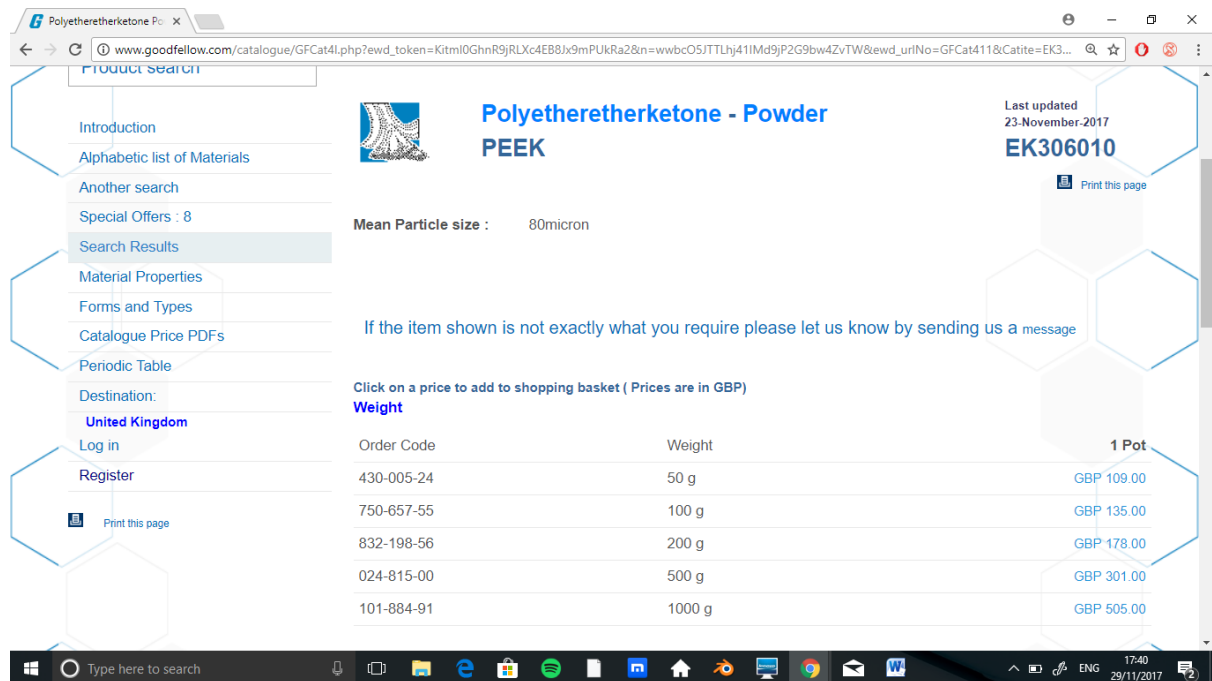
The overall time it takes to produce a part is dependent on the volume of the part. This is due to the thickness of each layer in the part. For example the SLS machine can produce up to 2mm to 3mm per hour in 0.1mm layers. One drawback that is relevant to the overall speed is that parts have to be left to cool which can increase cycle time by 50%. (Thompson, 2007 p. 236).

There are benefits with how no support structures are needed for SLS parts, since you are able to construct multiple parts in the building chamber (depending on size of the chamber) with precise accuracy and at different types. This decreases actual prototype constructing time since you save a lot of time in the development stage which indicates why SLS is such a popular rapid prototyping technique. In general it is a rather slow process but if you use the machine to its full potential such as making multiple parts together.

Cost

The cost of SLS prototyping is based on how long it takes for the part build time. Single part manufacturing is not recommended since if multiple parts are printed all together it can reduce cost. Labour costs are quite low in general but it does depend on choice of materials and when it comes to cleaning down the part.

The cost of buying SLS material varies for example



Polyetheretherketone - Powder
PEEK

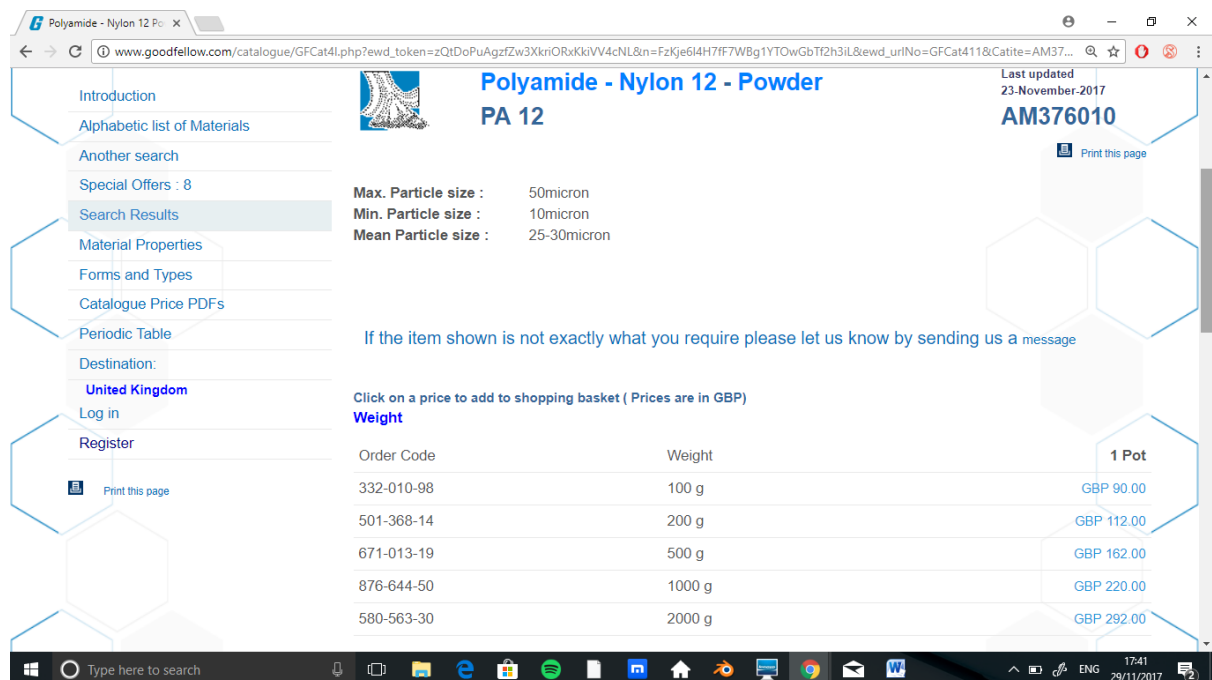
Last updated 23-November-2017
EK306010

Mean Particle size : 80micron

If the item shown is not exactly what you require please let us know by sending us a message

Click on a price to add to shopping basket (Prices are in GBP)

Order Code	Weight	1 Pot
430-005-24	50 g	GBP 109.00
750-657-55	100 g	GBP 135.00
832-198-56	200 g	GBP 178.00
024-815-00	500 g	GBP 301.00
101-884-91	1000 g	GBP 505.00



Polyamide - Nylon 12 - Powder
PA 12

Last updated 23-November-2017
AM376010

Max. Particle size : 50micron
Min. Particle size : 10micron
Mean Particle size : 25-30micron

If the item shown is not exactly what you require please let us know by sending us a message

Click on a price to add to shopping basket (Prices are in GBP)

Order Code	Weight	1 Pot
332-010-98	100 g	GBP 90.00
501-368-14	200 g	GBP 112.00
671-013-19	500 g	GBP 162.00
876-644-50	1000 g	GBP 220.00
580-563-30	2000 g	GBP 292.00

The actual cost of using a SLS printer is measured by many factors which include part size, space used in the machine, material used and etc. Therefore it's not easy to pin point the actual pricing, below is an example from a company website showing they price they service.



- **Maximum product size:** 330 x 330 x 250mm
- **Minimum order value:** £30
- **CAD Files accepted:** ACIS (*.sat), Inventor (*.ipt), CATIA V4 & V5 (*.model & *.catpart), Creo (*.prt), IGES, OBJ, Parasolid (*.x_t), Pro/Engineer (*.prt), Rhino (*.3dm), Siemens NX (*.prt), Solid Edge (*.par), SolidWorks (*.sldprt), STEP, STL
- **Finishing Options:** 10 Colour options and vibro finishing
- **Materials:** Nylon (PA2200). Glass Filled Nylo



There is also a link to another website [3faktur](#)

Volume of production

At the moment SLS is mainly used in low /batch volume production and prototype manufacturing. Since there is no need for tooling you can go straight in to production after the prototyping is complete due to how you can only need a CAD design to start production. The benefit of using SLS for prototyping is that it reduces the time it takes for a product to reach the market.

Examples of companies that provide the manufacturing process



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<https://twitter.com/3TRPD>

<https://en-gb.facebook.com/3T-RPD-Ltd-184362674909142/>

<https://www.linkedin.com/company/3t-rpd-ltd>

3T RPD® is a market leading production Additive Manufacturing company providing 3D printing services for customers in a range of industries including aerospace, motorsport (F1) and

the medical sector. We manufacture production quantity parts for end usage alongside one-off or prototypes in a range of metal alloys and plastics.

Using layer based laser technologies, Selective Laser Sintering and Direct Metal Laser Sintering (DMLS) are fast, cost-effective and extremely accurate manufacturing processes. Inspiring designers and engineers to create parts specifically for the AM process, they are freed up from previous design constraints. Built directly from 3D CAD data, they negate the need for conventional tooling, and parts can be optimised to retain structural strength whilst reducing their weight. This is providing attractive benefits to industries such as Aerospace, Automotive, Architectural, Defence, Medical, Luxury and Consumer Goods.

We offer a range of plastic and metal materials for our 3D printing services, including high performance alloys such as Aluminium, Titanium and Inconel, and have some of the world's largest plastic and metal machines. Our team of experienced engineers and skilled finishers ensure every last detail is taken care of, and we offer an extensive range of plastic and metal finishing techniques to satisfy all of our customers' rapid prototype and end use production requirements.

Above information from the company's website

Materials used by this company

Plastic:

Nylon 12

By far the most common laser sintering material, parts have good long term stability, offering resistance to most chemicals. Complexity is irrelevant. Delivers the impact strength and durability required for functional testing. Tensile and flexural strength combine to make tough prototypes, with the flex associated with many production thermoplastics.

Glass Filled Nylon 12

Glass Filled variant of Nylon 12. This laser sintering material provides greater rigidity, perfect when prototyping rigid parts intended for production in advanced engineered thermoplastics, and is the right choice for functional testing. Form, fit and functional testing can now be completed without sacrifice. The filler is glass bead and not fibre; part predominantly increases in stiffness but not strength

Flame Retardant Nylon 12

PA 2241 FR is a flame retardant polyamide 12. This 3D printing material contains a halogen-based flame retardant. In the event of a fire, the inert gas, halogen, is released which starves the flames of oxygen and so extinguishes them. The PA 2241 FR powder has been tested to JAR/FAR (aviation) for flammability and smoke generation. The built material has excellent mechanical properties and good tensile strength. It is expected that flame retardant plastic

AM parts will be ordered by customers who want end use, production volume parts for use in, for example, public transport, construction or the electrical and electronics sectors. It is an excellent laser sintering material for customers wanting legacy parts where the original tooling moulds have been lost or damaged. Mainly due to its recyclability, the material is economical, enabling low-cost part production.

Metals:

Aluminium AlSi10Mg

Aluminium AlSi10Mg is a typical casting alloy used for parts with thin walls and complex geometry. It offers good strength, hardness and dynamic properties and is therefore also used for parts that are subject to high loads. Parts in Aluminium AlSi10Mg are ideal for applications which require a combination of good thermal properties and low weight. AlSi10Mg can be machined, spark-eroded, welded, micro shot-peened, polished and coated if required.

Cobalt Chrome Alloy Co28Cr6Mo

Cobalt Chrome Alloy Co28Cr6Mo is a fine powder mixture which produces parts in a cobalt-chrome-molybdenum based super-alloy. Co28Cr6Mo is a class of super-alloy is characterised by having excellent mechanical properties (strength, hardness etc.), corrosion and temperature resistance. Such alloys are commonly used in biomedical applications such as dental and medical implants and also for high-temperature engineering applications such as in aero engines.

Nickel Alloy In718

Nickel Alloy In718 is a nickel based heat resistant alloy in fine powder form.. This kind of precipitation-hardening nickel-chromium alloy is characterized by having good tensile, fatigue, creep and rupture strength at temperatures up to 700oC. In718 also has outstanding corrosion resistance in various corrosive environments. This material is ideal for many high temperature applications such as gas turbine parts, instrumentation parts, power and process industry parts etc.

To access data sheets from 3trpd click on plastic or metal link above and select the read more about material on webpage.



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[https://www.facebook.com/Graphite-Additive- Manufacturing-Limited-259172320945977/](https://www.facebook.com/Graphite-Additive-Manufacturing-Limited-259172320945977/)

https://twitter.com/Graphite_AM

Graphite is a 3D printing consultancy that specialises in building complex designs and high-performance components in tailored materials.

Graphite Additive Manufacturing is a 3D printing consultancy for companies that want to make more of the potential of additive manufacturing. We work closely with engineers, model makers, industrial designers and product designers to test concepts, improve designs, cut production costs and solve complex design challenges.

Reliable – 99.45% parts shipped on time in the last 6 months

Flexible – We can build in part volumes between 1 and 10,000

Precise – We orientate each part for optimum surface quality and accuracy as standard

Consistent – We build and measure calibration parts on every build

Fast – 90% of parts can be produced within 3 days

Selective laser sintering (SLS) produces tough parts with high temperature resistance that are stable over time. SLS is often the technology we use for producing end-use parts. We have also developed sealing techniques to make our parts air tight, and water or chemical resistant.

To ensure your components have the mechanical properties you have specified, we build and test mechanical test bars on every SLS build. The mechanical data we publish is always from actual results, as opposed to taken from the manufacturers' data sheets.

3D printing is perfectly suited to manufacturing highly customised or limited runs of parts and final products. Digital manufacturing, as it is also known, enables our clients in many different industries to build parts and products without needing to invest in tooling, die casting, setting up traditional

manufacturing systems or machining. The potential of 3D printing to add complexity or lower part count can make this route even more cost effective.

We can build parts in exceptionally strong and light materials with excellent definition. You can design in functionality from the start, building features such as screw threads, oil ways and sealing grooves into the component, and eliminating the need for post machining processes. We can also seal parts to make them airtight, chemical or water-resistant.

The above information is from the company's website

Example of products



Full size engine 3d printed by graphite

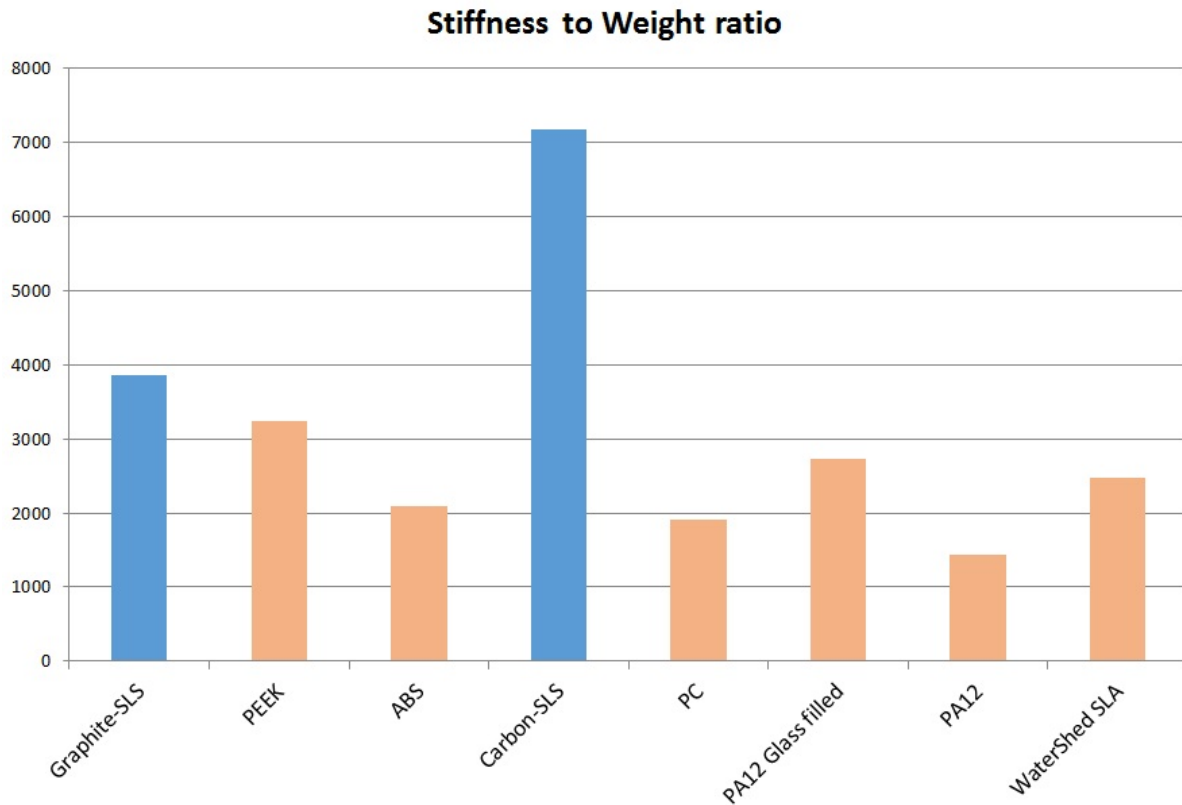
Materials used by this company

Carbon SLS – Carbon Fibre Reinforced Plastic

A specialised carbon fibre filled plastic ideal for functional components that need to be light and strong. It has the highest strength-to-weight and stiffness-to-weight ratios of any 3D printed plastic. Graphite Additive Manufacturing is the only 3D printing bureau in the UK that offers Carbon SLS.

Graphite SLS – Graphite Reinforced Plastic

A cost-effective all round material with an excellent black surface finish and mechanical properties. Lighter than comparable glass-filled nylon materials. This material was developed in-house and is exclusive to Graphite Additive Manufacturing.



The above information is from the company's website



Wycombe Sands, Lane End Road, High Wycombe, Bucks HP12 4HH

Email crdm@3dsystems.com

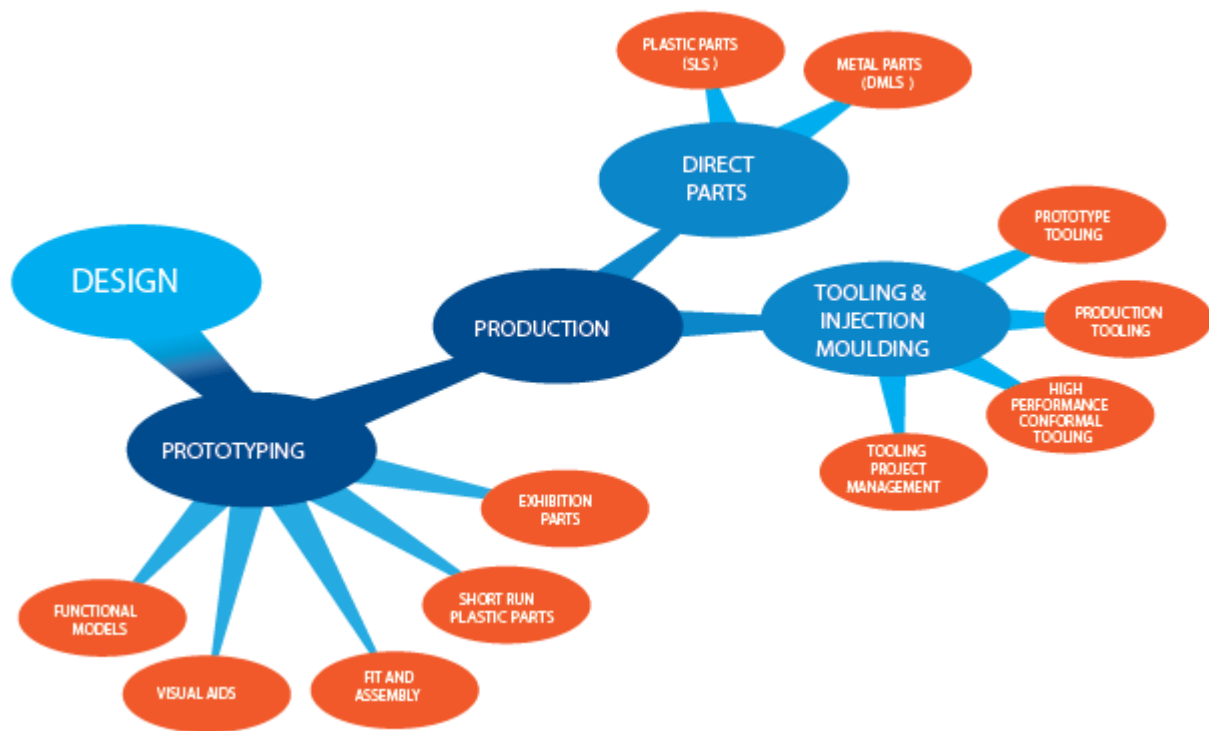
Tel **08450 514900**

Fax **08450 514901**

CRDM Delivery Service <https://www.facebook.com/3dsystemscorp>

CRDM uses a wide range of 3D CAD driven rapid prototyping and ALM technology combined with advanced CNC, wire and spark erosion to deliver components quickly and efficiently, with all processes accredited to the ISO 9001:2008 quality assurance standard.

CRDM SERVICE MAP This is what we do



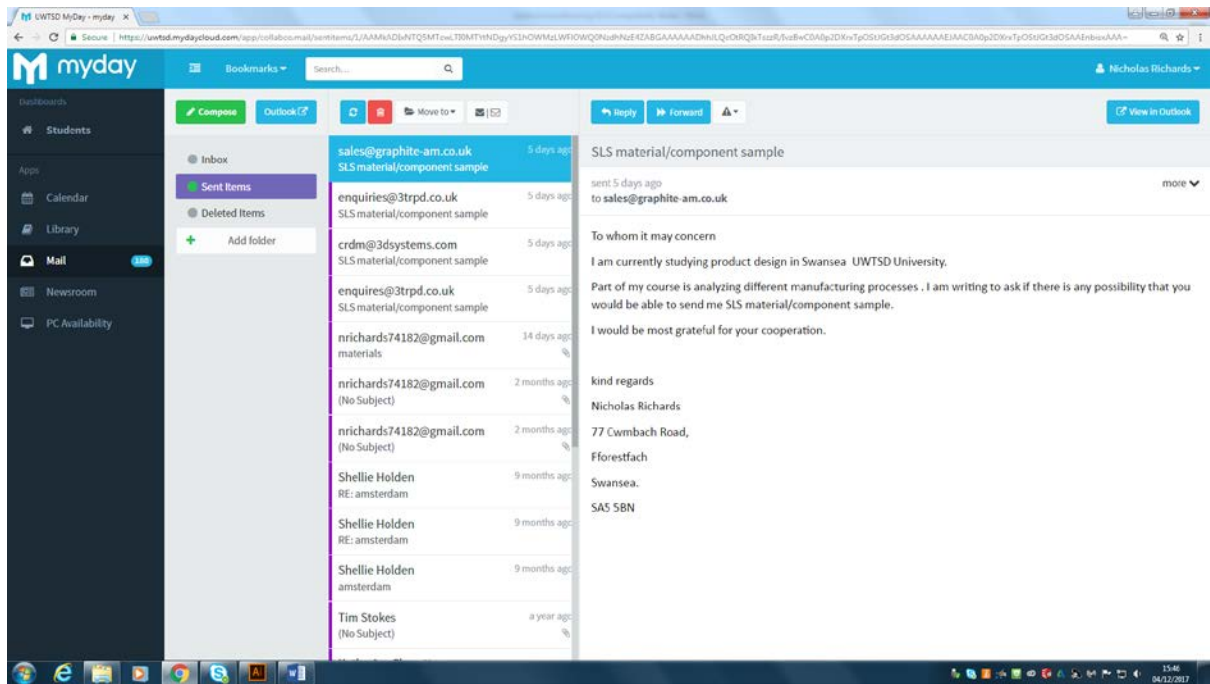
As the UK's foremost provider of 3D printing, rapid prototyping and tooling services for industry, across sectors including automotive, aerospace, medical and defence we can offer expert guidance from your initial design concept with advice from our skilled CAD technicians, through prototyping and functional models to small scale production or project managed high performance tools and mouldings.

Materials used by this company

[PA12 \(for more info\)](#)

Polyamide 12 (PA12) is a well-known plastic normally used for the injection moulding of parts intended for engineering applications. By adding glass beads, a glass filled composite is produced. This LS-PA12GF material produces stiffer and stronger components than natural LS-PA12 although these advantages are gained at the expense of a reduction in the elongation to break.

Above info from company website



prove of trying to obtain samples from compaines.

<http://rapidprototypingservicescanada.com/selective-laser-sintering-sls.php>

<https://www.3trpd.co.uk/>

<http://graphite-am.co.uk/>

<http://graphite-am.co.uk/wp-content/uploads/2017/03/Full-size-engine-model-.png>

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<http://www.planfab.eu/price-calculator/>

<http://crdm.co.uk/wp-content/themes/crdm/images/crdm-logo-new.jpg>

<http://crdm.co.uk/about-us/>

<http://crdm.co.uk/services/>

<http://crdm.co.uk/wp-content/uploads/2013/05/SLS-PA12GF.pdf>

<https://www.3dhubs.com/knowledge-base/how-design-parts-sls-3d-printing>

<https://www.3dhubs.com/knowledge-base/how-design-parts-sls-3d-printing#post-processing>

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