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Sustainability Investing

Manufacturing enters a new dimension

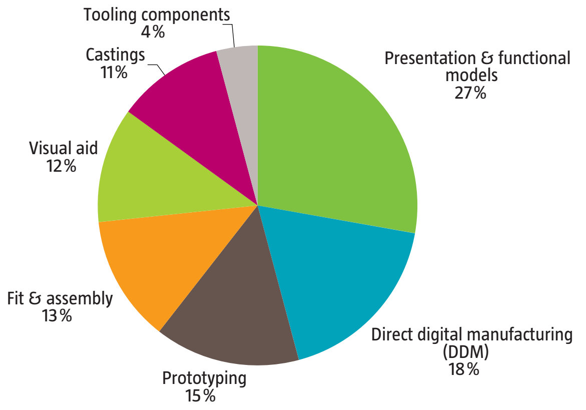
With the recent proliferation of new printing technologies, 3D printing has captured the public's imagination and is poised to transform manufacturing processes. Christophe Churet, Senior Analyst for the RobecoSAM Smart Materials Strategy, discusses some of the key benefits of 3D printing.

In an increasingly resource-constrained world, innovation is critical to becoming more energy efficient, doing more with less and finding substitutes for scarce materials, ultimately ensuring sustained economic growth. Additive manufacturing – more commonly known as 3D-printing – is a prime example of such an innovation. Though it has been around since the early 1980's, only recently has 3D printing begun to gain attention.

But what is it exactly, and how does it work? Simply put, additive manufacturing slices a 3D design file into hundreds of 2D cross-sections and builds a product one layer at a time in an additive fashion. This differs from traditional machining techniques, which cut away from a given raw material through drilling or milling to manufacture a product in a subtractive process.

A number of factors have contributed to the recent acceleration in demand for 3D printing. The first has been the increasing sophistication of computer-aided design (CAD) and related software tools.

Figure 1: Uses of additive manufacturing



Such design files are a key 'input' to 3D printers. In particular, the transition from 2D to 3D design tools, which only occurred in earnest over the past 10-15 years, was a key catalyst to the advent of 3D printing. But the most important driver for additive manufacturing has been the rapid improvements in cost and performance specifications of 3D printers, making this technology increasingly competitive versus traditional machining techniques.

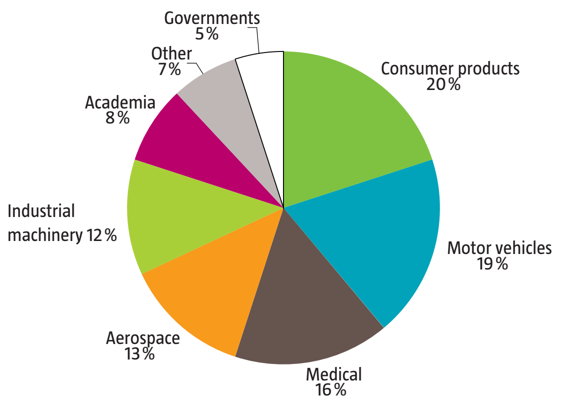
Primary applications

What are the main uses of additive manufacturing today? As shown in Figure 1, over 50% of the uses of 3D-printing are still associated with prototyping and related activities rather than for the actual manufacture of products. Technologies such as CAD tools and 3D printers offer companies a number of clear benefits for prototyping and the development of new products. Such technologies have pioneered faster, more advanced and less costly design processes, fostering product innovation, reducing time-to-market and enhancing profitability. In addition, manufacturers are now better able to simulate and test products' properties early in the development phase, reducing design errors, improving overall product quality and limiting the risk of product recalls.

Such advances in how companies develop new products should not be underestimated. Still, many expect the most important growth driver for 3D printing going forward to be the actual manufacture of parts, components and finished products, which is referred to as Direct Digital Manufacturing (DDM).

Interestingly, DDM applications are emerging in numerous industries, including industrial, medical, and consumer discretionary. As shown in Figure 2, industrial applications currently dominate the use of 3D printing for DDM, with motor vehicles, aerospace, and machinery accounting for nearly 50% of total uses. For instance, GE Aviation recently announced the acquisition of two 3D printing companies, Morris Technologies and Rapid Quality Manufacturing, with a focus on the production of jet engine parts. Similarly, BMW has already

Figure 2: Uses of Direct Digital Manufacturing



replaced a number of traditional computer numerical control (CNC) machining techniques with 3D printers to manufacture jigs and fixtures required for automobile assembly.

While still at an early stage, medical applications for 3D printing also offer bright prospects in two distinct areas. First, advances in scan-to-print technologies are enabling doctors and surgeons to better examine and interpret medical data before making a diagnosis and moving on to treatment or more invasive surgery. Second, 3D printing can potentially contribute to huge advances in our ability to customize parts such as prosthetics and components for bone and joint repair–though such uses currently remain challenged by the limitations in materials usage and their durability, as well as lengthy regulatory approval processes. Still, dental applications already represent a sizable portion of uses of additive manufacturing for DDM.

Massive advances have also been made in the consumer end-market for 3D printing, which has witnessed substantial growth in recent years. This growth has been driven by a growing awareness of this technology coupled with the rapid development of lower-cost 3D printers, such as 3D Systems' Cube product line. In addition, the emergence of public, low-end CAD databases and other open source software has vastly increased the availability of predesigned models to end-users. Interestingly, this is an area in which companies' strategies vary considerably, with 3D Systems Corp. clearly pursuing this market, while competitors appear more focused on high-end professional systems.

Key Benefits

Used in combination with CAD and related software tools, 3D printers are transforming how companies think about product development and prototyping. Second, the use of 3D printing for direct digital manufacturing (DDM) can save costs by enabling the more efficient use of raw materials because it manufactures products in an additive manner, rather than in a subtractive manner, which often results in excess material that is discarded. Equally important, DDM can greatly influence how companies manage their supply chains and inventories – especially their spare parts and components. The possibility of insourcing the production of spare parts, effectively holding a 'digital inventory' of such components at production sites, could prove to be an attractive proposition, particularly for companies operating in complex value chains characterized by long lead times. Last, 3D printing technologies further push the frontier of the customization and miniaturization of products in a variety of end-markets, including industrial, medical, and consumer.

Investment considerations

What are some key considerations when investing in the 3D printing space? First, 3D printing encompasses a wide range of technologies, each having various strengths and weaknesses relating to the usability of different types of materials, product quality, build speed, and build chamber dimensions. One important factor to consider as 3D printing transitions from prototyping to DDM is build speeds, which ultimately dictate throughput and will thus largely influence the economic competitiveness of 3D printing versus traditional manufacturing techniques.

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A number of 3D printing technologies appear particularly promising. Both stereolithography (SLA) and digital light processing (DLP) are established technologies that use certain wave lengths of light to expose resins and/or polymers to build a product. Both produce accurate results and are able to deal with highly complex shapes and forms, making them ideal for prototyping. The more recent Inkjet technology, a process that involves multiple jetting heads that spray liquid polymers that are instantly cured with ultra violet (UV) lamps, appears particularly promising in that it is able to provide high-quality surface finishing while also being one of the fastest 3D printing technologies available on the market. Last, selective laser sintering (SLS), a technology that uses high power lasers to fuse small particles of powder to produce a given shape, also stands out due to its ability to handle a wide range of materials including plastics, metals, ceramics and glass powders.

Figure 3 provides additional details on the most widely used additive manufacturing technologies, as well as their respective pros and cons.

Figure 3: Additive manufacturing technologies

Process	Description	Example Materials	Pros	Cons
Digital Light Processing (DLP)	Light exposed polymer	liquid resin, polymer	Similar to SLA quality; can produce high quality and complex geometries	Parts are generally weaker than other methods
Electron Beam Melting (EBM)	Melting metal powder using electron beam in high vacuum	metals, titanium alloy	Fully dense (100 %) and extremely durable, no post thermal treatment required	Poor surface finish combined with expensive materials
Fused Deposition Modeling (FDM)	Fused extrusions	ABS, PC, PC/ABS, PPSU	Parts are relatively strong and can be good for some functional testing; can make complex geometries	Poorer surface finish and slower build times than SLA and SLS
Inkjet	UV cured jetted photopolymer	acrylic based photopolymers, elastomeric photopolymers	Yields the best surface finish of additive processes and is the best choice for complex parts with undercuts	Poor strength compared to SLA.
Powder Binding	Liquid binder inkjet printed onto powder	plaster-based powder/liquid binder	Fastes time of any additive process; can print in multiple color combos and is one of the least expensive options for prototyping	Parts are rough and less durable and there are fewer material options
Stereolithography (SLA)	Laser cured photopolymer	thermoplastic-like photopolymers	Can produce parts with complex geometries and excellent surface finishes compared to other additive processes	Parts are weaker than those made from engineering grade resins; typically unsuitable for functional testing
Selective Laser Sintering (SLS)	Laser sintered powder	nylon, metals	More accurate and durable than SLA parts; can make parts with complex geometries	Surface finish not smooth (grainy) and typically not suitable for functional testing due to their reduced mechanical properties

Source: Piper Jaffray (2013)

Investors should also be aware of the importance of market leadership and the size of companies' installed base of 3D printers, as the real attractiveness of these business models is the sale of high-margin consumable materials. In recent years, leading 3D printing firms have made the strategic move to make consumables proprietary to individual 3D printers, effectively blocking out potential third-party materials sellers. This is a positive strategic move, as high consumer switching costs and proprietary consumable materials offer the most significant sources of sustained competitive advantages to 3D printing companies.

Additive manufacturing offers many of the conditions necessary for successful long-term investments, provided that individual company stocks are purchased at an attractive valuation. As long as costs and performance specifications continue to improve 3D printing has solid prospects for transitioning from a prototyping tool to the direct digital manufacturing of finished products. In the short-run, DDM will continue to focus on low-volume, high-value parts and components. But in the not too distant future, as the technology becomes cheaper, faster, and as DDM technology evolves to accommodate more types of materials, significant chunks of the existing market for traditional machining processes such as injection molding could be affected. Additive manufacturing technology clearly has the potential to be highly disruptive, and 3D printing companies such as 3D Systems Corp., Stratasys Ltd., and ExOne Co., as well as software firms such as Autodesk, Inc., Dassault Systemes S.A., and Ansys, Inc. are well-positioned to benefit from its wider adoption.

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