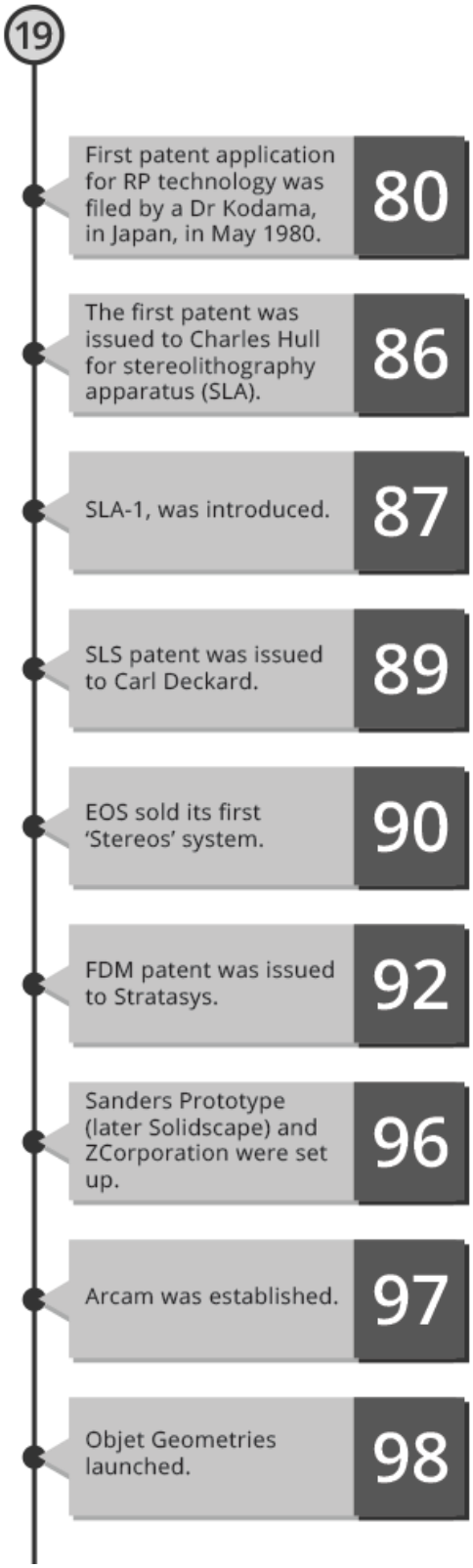
History of 3D Printing: The Free Beginner's Guide

The earliest 3D printing technologies first became visible in the late 1980's, at which time they were called Rapid Prototyping (RP) technologies. This is because the processes were originally conceived as a fast and more cost-effective method for creating prototypes for product development within industry. As an interesting aside, the very first patent application for RP technology was filed by a Dr Kodama, in Japan, in May 1980. Unfortunately for Dr Kodama, the full patent specification was subsequently not filed before the one year deadline after the application, which is particularly disastrous considering that he was a patent lawyer! In real terms, however, the origins of 3D printing can be traced back to 1986, when the first patent was issued for stereolithography apparatus (SLA). This patent belonged to one Charles (Chuck) Hull, who first invented his SLA machine in 1983. Hull went on to co-found 3D Systems Corporation — one of the largest and most prolific organizations operating in the 3D printing sector today.

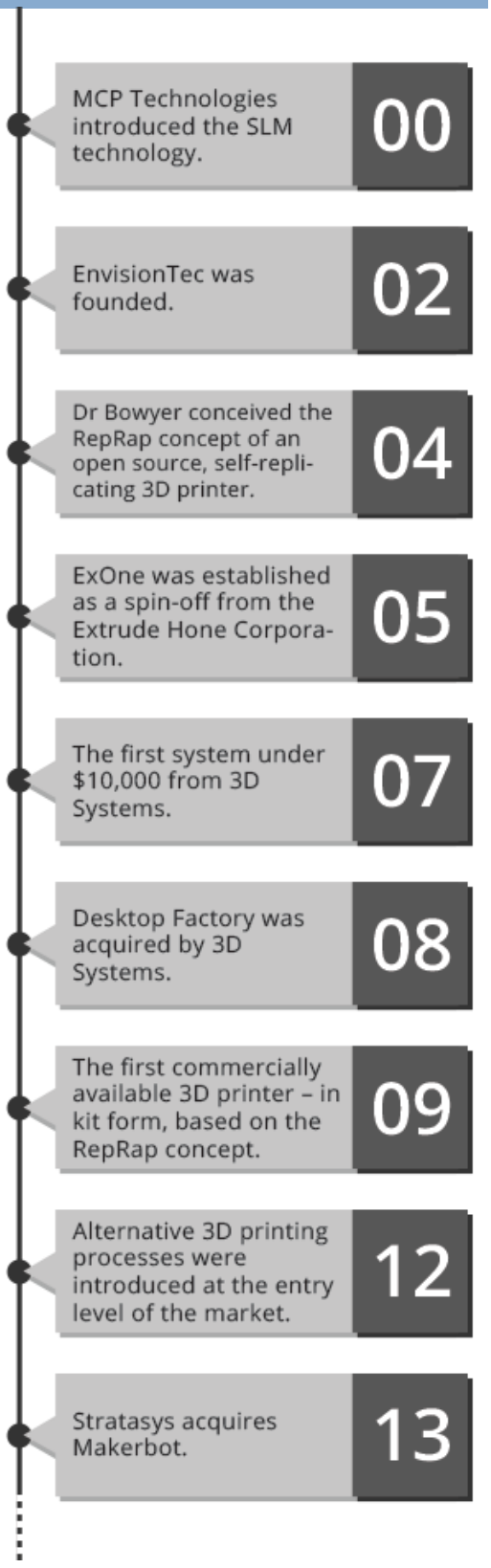
3D Systems' first commercial RP system, the SLA-1, was introduced in 1987 and following rigorous testing the first of these system was sold in 1988. As is fairly typical with new technology, while SLA can claim to be the first past the starting post, it was not the only RP technology in development at this time, for, in 1987, Carl Deckard, who was working at the University of Texas, filed a patent in the US for the Selective Laser Sintering (SLS) RP process. This patent was issued in 1989 and SLS was later licensed to DTM Inc, which was later acquired by 3D Systems. 1989 was also the year that Scott Crump, a co-founder of Stratasys Inc. filed a patent for Fused Deposition Modelling (FDM) — the proprietary technology that is still held by the company today, but is also the process used by many of the entry-level machines, based on the open source RepRap model, that are prolific today. The FDM patent was issued to Stratasys in 1992. In Europe, 1989 also saw the formation of EOS GmbH in Germany, founded by Hans Langer. After a dalliance with SL processes, EOS' R&D focus was placed heavily on the



laser sintering (LS) process, which has continued to go from strength to strength. Today, the EOS systems are recognized around the world for their quality output for industrial prototyping and production applications of 3D printing. EOS sold its first 'Stereos' system in 1990. The company's direct metal laser sintering (DMLS) process resulted from an initial project with a division of Electrolux Finland, which was later acquired by EOS.

Other 3D printing technologies and processes were also emerging during these years, namely Ballistic Particle Manufacturing (BPM) originally patented by William Masters, Laminated Object Manufacturing (LOM) originally patented by Michael Feygin, Solid Ground Curing (SGC) originally patented by Itzchak Pomerantz et al and 'three dimensional printing' (3DP) originally patented by Emanuel Sachs et al. And so the early nineties witnessed a growing number of competing companies in the RP market but only three of the originals remain today — 3D Systems, EOS and Stratasys.

Throughout the 1990's and early 2000's a host of new technologies continued to be introduced, still focused wholly on industrial applications and while they were still largely processes for prototyping applications, R&D was also being conducted by the more advanced technology providers for specific tooling, casting and direct manufacturing applications. This saw the emergence of new terminology, namely Rapid Tooling (RT), Rapid Casting and Rapid Manufacturing (RM) respectively.



In terms of commercial operations, Sanders Prototype (later Solidscape) and ZCorporation were set up in 1996, Arcam was established in 1997, Objet Geometries launched in 1998, MCP Technologies (an established vacuum casting OEM) introduced the SLM technology in 2000, EnvisionTec was founded in 2002, ExOne was established in 2005 as a spin-off from the Extrude Hone Corporation and Sciaky Inc was pioneering its own additive process based on its proprietary electron beam welding technology. These companies all served to swell the ranks of Western companies operating across a global market. The terminology had also evolved with a proliferation of manufacturing applications and the accepted umbrella term for all of the processes was Additive Manufacturing (AM). Notably, there were many parallel developments taking place in the Eastern hemisphere. However, these

technologies, while significant in themselves and enjoying some local success, did not really impact the global market at that time.

During the mid noughties, the sector started to show signs of distinct diversification with two specific areas of emphasis that are much more clearly defined today. First, there was the high end of 3D printing, still very expensive systems, which were geared towards part production for high value, highly engineered, complex parts. This is still ongoing — and growing — but the results are only now really starting to become visible in production applications across the aerospace, automotive, medical and fine jewellery sectors, as years of R&D and qualification are now paying off. A great deal still remains behind closed doors and/or under non-disclosure agreements (NDA). At the other end of the spectrum, some of the 3D printing system manufacturers were developing and advancing 'concept modellers', as they were called at the time. Specifically, these were 3D printers that kept the focus on improving concept development and functional prototyping, that were being developed specifically as office- and user-friendly, cost-effective systems. The prelude to today's desktop machines. However, these systems were all still very much for industrial applications.

Looking back, this was really the calm before the storm.

At the lower end of the market — the 3D printers that today are seen as being in the mid range — a price war emerged together with incremental improvements in printing accuracy, speed and materials.

In 2007, the market saw the first system under $10,000 from 3D Systems, but this never quite hit the mark that it was supposed to. This was partly due to the system itself, but also other market influences. The holy grail at that time was to get a 3D printer under $5000 — this was seen by many industry insiders, users and commentators as the key to opening up 3D printing technology to a much wider audience. For much of that year, the arrival of the highly-anticipated Desktop Factory — which many predicted would be the fulfillment of that holy grail — was heralded as the one to watch. It came to nothing as the organization faltered in the run up to production. Desktop Factory and its leader, Cathy Lewis, were acquired, along with the IP, by 3D Systems in 2008 and all but vanished. As it turned out though, 2007 was actually the year that did mark the turning point for accessible 3D printing technology — even though few realized it at the time — as the RepRap phenomenon took root. Dr Bowyer conceived the RepRap concept of an open source, self-replicating 3D printer as early as 2004, and the seed was germinated in the following years with some heavy slog from his team at Bath, most notably Vik Oliver and Rhys Jones, who developed the concept through to working prototypes of a 3D printer using the deposition process. 2007 was the year the shoots started to show through and this embryonic, open source 3D printing movement started to gain visibility.

But it wasn't until January 2009 that the first commercially available 3D printer – in kit form and based on the RepRap concept – was offered for sale. This was the BfB RapMan 3D printer. Closely followed by Makerbot Industries in April the same year, the founders of which were heavily involved in the development of RepRap

until they departed from the Open Source philosophy following extensive investment. Since 2009, a host of similar deposition printers have emerged with marginal unique selling points (USPs) and they continue to do so. The interesting dichotomy here is that, while the RepRap phenomenon has given rise to a whole new sector of commercial, entry-level 3D printers, the ethos of the RepRap community is all about Open Source developments for 3D printing and keeping commercialization at bay.

2012 was the year that alternative 3D printing processes were introduced at the entry level of the market. The B9Creator (utilising DLP technology) came first in June, followed by the Form 1 (utilising stereolithography) in December. Both were launched via the funding site Kickstarter — and both enjoyed huge success.

As a result of the market divergence, significant advances at the industrial level with capabilities and applications, dramatic increase in awareness and uptake across a growing maker movement, 2012 was also the year that many different mainstream media channels picked up on the technology. 2013 was a year of significant growth and consolidation. One of the most notable moves was the acquisition of Makerbot by Stratasys.

Heralded as the 2nd, 3rd and, sometimes even, 4th Industrial Revolution by some, what cannot be denied is the impact that 3D printing is having on the industrial sector and the huge potential that 3D printing is demonstrating for the future of consumers. What shape that potential will take is still unfolding before us.

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