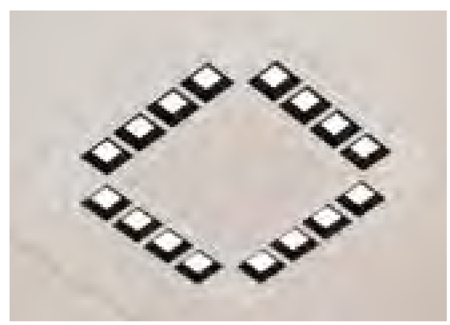
SUNY NEW PALTZ – HVAMC | BY DAN FREEDMAN, KAT WILSON AND AARON NELSON

3D Printing Updates from the Hudson Valley Advanced Manufacturing Center

We've reached the fifth anniversary of the start of the Hudson Valley Advanced Manufacturing Center the time is right for an update on 3D printing and the significant expansion underway in the HVAMC. I would first like to thank the Council of Industry and its members for all of their support over the last five years. A key mission of the HVAMC is to support local businesses, but there's a lot we had to learn about the broad range of applications that 3D printing can be used for and manufacturing in general and we really appreciate everyone's patience and willingness to provide feedback.

We started with the very simple idea that 3D printing is a technology where the applications are well behind its capabilities. Through maintaining state-of-the-art equipment and focusing on practical applications, we have developed into one of the top academic 3D printing labs in the country and one of the few dedicated to solving practical problems for industry.

When we first got started five years ago, we were in the middle of the 3D printing hype where additive manufacturing was forecast to quickly replace traditional forms of manufacturing. We were soon to be printing food, prosthetics, replacement livers and kidneys, houses, etc.



LED lighting display at Selux showroom in Highland, NY showing baffles 3D printed out of PC/ABS on a Stratasys Fortus 400mc.

As you have probably noticed, these changes have mainly not happened. Why? Well, there are a couple of core reasons:

1. 3D printing is slow. A common statement we hear is that "3D printing is slow, but I'm sure that will change quickly." It hasn't. If you are surprised by this, just ask yourself how much faster are milling machines than they were 20 years ago?

2. 3D printing can only achieve decent tolerance. Our professional-level Stratasys machines print reliably to 0.005" tolerance. Our desktop printers can't reliably get better than 0.030" tolerance without tweaking each individual print.

3. There are significant material limitations. We can print a lot of useful industrial thermoplastics but not, for instance, polyethylene, polypropylene or a true nylon. This is changing rapidly with new materials coming out regularly.

4. Any food you can print with a 3D printer is likely to taste horrible. Except for chocolate.

The utility of 3D printing is demonstrated by the over 300 companies and individuals that we've worked with over the past 5 years. During the hype phase, the Venture Capital community kept looking for a "killer app" for 3D printing, meaning a single application with a large market. I think there was a failure to really understand that the importance of 3D printing was that it made it possible to make almost any unique object quickly. This means 3D printing can be used in many, many fields. The problem, from the point of view of commercialization, is that many potential customers didn't understand where it fit into their business and the folks with the expertise in 3D printing couldn't afford to spend the time to explain its importance. This is an ideal situation for an academic lab because it all comes down to education and exploration. This approach has worked in that our 300+ customers include a number of manufacturers (including 14 CI companies) artists, designers, architects, entrepreneurs, inventors, fabricators, a chocolatier and one bank.

Real world examples are always the best. The photographs show two interesting 3D printing applications from two CI companies, Selux and Schatz Bearing Corporation. Both are in the two most important 3D printing applications of "prototypes" and "tooling" … but with a twist. The first is in Selux's impressive showroom at their site in Highland. The parts that we printed are the black baffles. This wasn't an overly complicated printing problem, but it's a nice example of our ability to do runs of final use parts in functional materials, in this case around 300 of them. Generally, 3D printing enables the production of larger assemblies for any number of reasons prior to tooling up for the mass production of parts through, for instance, injection molding. The second set of pictures is a feeder assembly at Schatz Bearing Corp. built to retrofit an existing machine. This was designed by Schatz, which includes an optical sensor, and printed at the HVAMC. The system allows an operator to run several machines at the same time because the 3D printed loading chute holds many more parts than the original design. These are just two examples of the large number of prototypes, molds, jigs, fixtures and artwork we have built over the years.

Bearing machine at Schatz Bearing Corp. with a feeder assembly 3D printed out of ABS+ on a Stratasys Dimension 1200ES.

Where are we going next? Thanks to a $500,000 award from the Dyson Foundation, a $200,000 award from Central Hudson and $50,000 in matching funding from local companies and New Paltz alumni and friends we are preparing for a massive upgrade in our equipment. We're adding a number of new thermoplastics printers that will increase our capacity and flexibility, a full color printer for prototyping and, the real big deal, a metal printer.

"Let me know when you can print metal". We've been hearing this in the HVAMC since we started. It's easy to understand why. Even though the wide range of thermoplastics that we can print have impressive properties, sometimes you just have to use metal. We will be installing our first metal printer this Spring.

Metal printing is not new. The first metal printing process, selective laser sintering (also known as selective laser melting) was invented in the mid-1990's and has been successfully commercialized by a number of companies. The basic process involves using a high-powered laser to selectively melt layers of fine metal powder. The resolution is very high with each layer being 20-50 microns thick and the X-Y resolution being limited by the width of the laser. The process has been used for prototyping and for final use parts, particularly in the aerospace and automobile industries. The drawback with the sintering process is the cost. The lowest end printers start at about $200,000 which only gives a build volume of about 5" x 5" x 5". The operating costs are also high because the metal powders are expensive and the printers need to run under an inert gas purge. In addition, the flammability of the powders, particularly with active metals like titanium and aluminum, creates some fairly significant health and safety issues. We have quoted several printing jobs in metal for HVAMC customers through some of the online service centers, but the cost is so high that the typical reaction is "thank you, I think we'll machine it".

The second type of metal printing process is powder-binder. In this process, each layer of metal powder is held together with an ink-jetted binder. This "green" part has to then be sintered to produce a final part. This is a much less expensive process and has considerable promise for producing larger parts and large numbers of small parts. The drawback has been that the sintered parts tend to have relatively low density and/or require sintering while buried in metal powder to infiltrate the voids. This method has considerable promise and a number of companies have a new version of this type of printer under development, particularly for high-volume metal printing.

The printer we have purchased is from a relatively new company called Desktop Metal. We are purchasing their Studio System. The process is a bit of a mixture of new and old technology. The materials used are off-the-shelf products developed for metal injection molding. This is a mixture of metal powder coated with a wax or polymer. Desktop Metal packages it into sticks that look like long, thin crayons. The material is then extruded at low temperatures (200˚-250˚C) using a printer that's very similar to our Stratasys thermoplastic printers. It prints in a build volume of 8" x 12" x 8" with, currently, a range of different steels (17-4 PH, AISI 4140, H13, 316L), copper and Inconel 625. More metals are in development. After the print is complete, the wax is removed through a chemical wash and then the part is sintered in an oven to 96+% density. The real trick in this whole process is predicting the shrinkage during the sintering process. Desktop Metal's software will build the part oversized to sinter down to the desired geometry. The expected tolerance is around 0.005". Since the shrinkage is anisotropic and dependent on the volume of the part, we expect that the tolerance will be somewhat geometry dependent. However, the capital and operating costs for the Desktop Metal system will reduce metal printing costs by almost 90% relative to laser sintering. We expect the print cost to be around \$20-30/in^3 for stainless steel. Note that the complexity of the part will have no bearing on the cost. Where we expect this to be useful is in the rapid turn-around of relatively small parts either for prototypes or for limited runs of final-use parts, essentially the same suite of applications that polymer 3D printers are used for.

In the HVAMC, we are very careful to not oversell what 3D printing can be used for. The claims that 3D printing will take over manufacturing are simply hype. However, 3D printing does have key uses in manufacturing and those uses will continue to expand. Like any fabrication technique, it takes some time to figure out what it can do and where it can be applied, and the HVAMC is dedicated to accelerating that process for the Hudson Valley manufacturing community.