Alan Pierce
pierceaj@techtoday.us; follow on Twitter @techtoday_us

3D Printing—From the Simple to the Complex

In 1988, a California company named 3-D Systems Inc. introduced a machine that could convert computer drawings directly into plastic models. My November 1998 column covered the 3-D Systems' process and how it was being used at the time. You can read this original column online at www.technologytoday.us/PastColumnPDFs/34_Rapid_Prototyping_&_Manufacturing_Nov_1998.pdf.

In less than three decades, 3-D Systems' expensive stereolithography printing process has evolved from a rapid prototyping and manufacturing technology to a very broad technology that includes relatively inexpensive 3D printing machines. 3D printing is now a process that anyone can use to replicate physical objects.

The price of 3D printers keeps dropping. You can now outfit a technology lab or home workshop for just a few thousand dollars. You don't even need your own 3D printer to create objects that you have designed. Shapeways.com and many other online companies will print your projects for you. If the term 3D printing is new to you, might want to watch this YouTube video to get a basic understanding of the process (www.youtube.com/watch?v=S-E6vRfnijw).

Once you have a 3D printer, you need 3D digital design files of the objects that you want to create. Your technical skills will determine if you use 3D design software to create your own designs or download free designs from an Internet site such as www.3dprinter.net/directory/free-3d-models. Your third option is to purchase your own 3D desktop digitizer. When this column went to press, the MakerBot digitizer had recently been announced to the press, but no photos or reviews of the machine were available. By the time you read this column, you might find images of their digitizer and a video that shows it in action on their website (http://store.makerbot.com/digitizer.html). The digitizing process will involve placing an original object on a stage so that the digitizer can scan it to create a digital file. The software that comes with a 3D printer will then use this file to print duplicates of your object.

Photo 1—Engine combustor 3D printed with every point matching the critical tolerance demanded by the engineers who designed it

Gene Roddenberry's *Star Trek* replicator could create tools, weapons, machine parts, food, and other nonliving physical objects. The question that was on my mind as I started to research this topic: How close have we come to Roddenberry's sci-fi replicator?

In May 2013, General Electric's aviation division started to build a new jet engine that contains many parts that are being fabricated through a 3D-printing process. The industrial 3D-printing process that GE is using has the more sophisticated name Additive Manufacturing. It is a 3D-printing machine on steroids.

Actually stereolithography, additive manufacturing, and 3D printing are simply different names for the same process. All 3D printers follow the building plan provided by a digital file. A computer tells the printer exactly where to place the feed stock (plastic, metal, food ingredients, etc.) to create three-dimensional objects one layer at a time. As the material is laid down, it is fused layer by layer. In the GE printers, the layers are fused together at extreme temperatures created by powerful lasers.

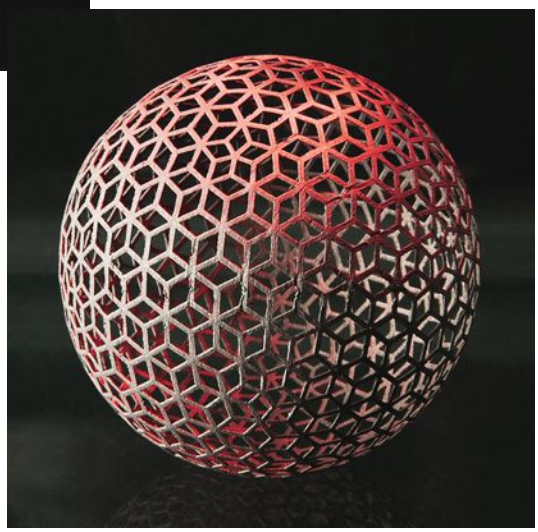

Photo 2—Titanium ball built to show the accuracy of 3D printing

Photos 1 and 2 courtesy General Electric Aviation

In time, you will find the engine GE is building on Boeing 737s, Airbus

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Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.

A320s, and other new airplanes still on the drawing board. The parts that GE aviation division is manufacturing with this process are much lighter, stronger, and more complex than the ones that they are replacing. It is questionable whether or not they could be manufactured using 20th-century technology. The new engines will burn 15% less fuel. The engine combustor shown in Photo 1 is one of the new engine parts. GE also made a titanium ball to show that this process can create extremely complex shapes quickly and accurately. (See Photo 2.)

Can our 3D-printing technologies today also produce objects that are biological in nature? Biotechnologists and scientists working in the clean rooms of a San Diego, CA, company named Organovo have recently created muscle tissue using a 3D printer. The feedstock for their experiment was human muscle cells. At the end of the 3D printing process these cells came together as a working muscle.

Their current goal is to create working muscles that can be used to test new drugs. Their future goal is to use the lung tissues, heart muscles, and human blood vessels that they are now learning to create to eventually build full organs. Imagine a replacement organ manufactured using the recipient's own cells! This technology would end the organ-matching process and the need for immunosuppressant drugs.

To show the full scope of our current 3D printing, I decided to end the column on a sweet note. People are now using these printers to create food shapes for baking and frying. The Sugar Lab basically proves that you can use these machines to create unbelievable taste delights out of sugar. (See Photo 3.)

Recalling the Facts

1. The *Star Trek* replicator was a fictional technology of the 23rd century. Do you think that the slower machines that are in use today can produce all of the objects that the fictional one did in *Star Trek*? Why or why not?

2. What kind of 3D printing do you think will exist 50 or 100 years from today? td

http://the-sugar-lab.com

Photo 3—If you can find a way to turn any ingredient, even sugar, into a feed stock, the Sugar Lab has proven that you can get a 3D printer to use it to create delightful shapes.