

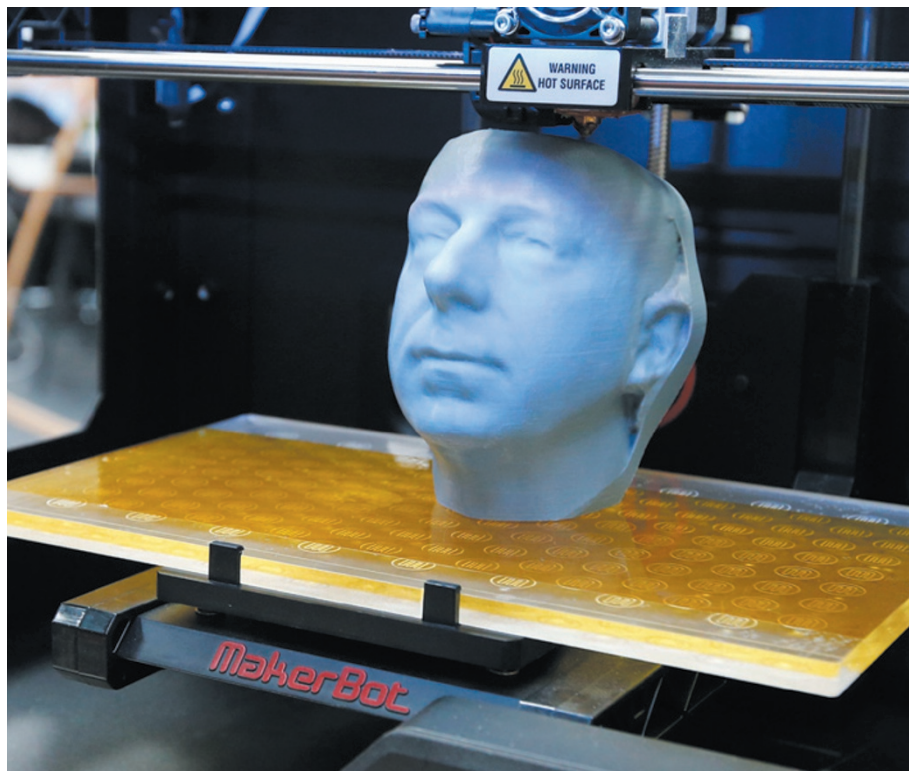
# CAREERS

**RESEARCH EFFICIENCY** Administrative tasks gobble scientists' time, says report **p.523**

**AWARDS** Prize winners invest their money in postdoc endowment **p.523**

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Three-dimensional printing is opening up applications in many areas, including research.

## TECHNOLOGY

# Building opportunities

*More jobs and research positions are being created as interest in 3D printing grows.*

BY NEIL SAVAGE

**K**iril Vidimč began his professional life as a software graphics engineer in California — he spent eight years at Pixar Animation Studios in Emeryville and another four at chip-maker Intel in Santa Clara. But he wanted to move beyond the world of animated movies and video games into something that existed outside of a video screen. So in February 2012, he joined the Computational Fabrication Group at Massachusetts Institute of

Technology in Cambridge. He's now pursuing a PhD in computational fabrication and writing software that tells three-dimensional (3D) printers how to build complicated objects.

"I'm excited about working on physical things for a change. I've never been a maker myself, but I always wanted to be. I wanted to play with more physical stuff," Vidimč says. "I think it's fun to get to the intersection where you're combining knowledge of computer science and electronics and materials."

Indeed, 3D printing, also known as

additive manufacturing, is a growing field that draws researchers from a variety of disciplines — computing, materials science, mechanical and electrical engineering, physics, chemistry, and even biology. They are in demand to develop the technology into something that might change how manufacturing is done and create all sorts of products that have not been possible before, from lighter-weight aircraft parts to cubes that unfold into furniture to 'biobots' made with living cells.

Wohlers Associates, a consulting firm in Fort Collins, Colorado, that focuses on the industry, says that the worldwide market for 3D printing products and services jumped to US\$3.1 billion in 2013 (a rise of 35% from 2012), and expects it to grow to \$10.8 billion by 2021. That will certainly open up more jobs in the field, says company president Terry Wohlers. "As the industry grows, so will the need for designers, scientists and researchers — especially chemists — to develop new materials," he says. "Also, we'll need mechanical and electrical engineers to develop new-generation 3D printers, manufacturing engineers to develop processes and supply chains and educators to introduce all of this to a new generation of designers, technicians and others."

Some of those jobs will be in the 30 or so companies that manufacture the printing systems in Europe, the United States, China and Japan. "The prospects of employment are very good," says Cathy Lewis, chief marketing officer at one of those companies, 3D Systems in Rock Hill, South Carolina, which lists numerous openings for engineers of different stripes. She says it's hard to project exact numbers of future hires, but points out that the company has grown from 300 employees four years ago to 1,500 today, many of them in technical positions.

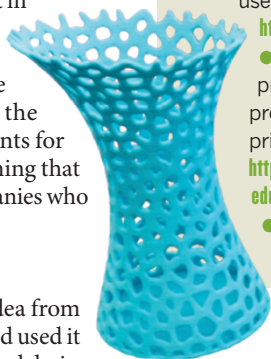
Governments around the world are pouring money into research projects intended to advance the technology of 3D printing from a niche field to a major part of manufacturing, providing funds to encourage partnerships between universities and industry. In 2012, for instance, the US government launched the National Additive Manufacturing Innovation Institute, since dubbed America Makes, based in Youngstown, Ohio, with \$30 million in government funding and another \$40 million from industry. The institute has given out \$13.5 million in matching funds to research teams from both industry and academia. The US National Science Foundation, the Defense Advanced Research Projects Agency and NASA are all also funding 3D printing research. ▶

► In 2013, the Singapore government announced that it would invest S\$500 million (US\$400 million) over five years in research into 3D printing and other innovative technologies such as robotics, and the Chinese government intends to invest \$240 million in 3D printing over three years. Last summer, the UK's Technology Strategy Board and the Research Councils announced £8.4 million (US\$14.22 million) in such funding. It is hard to say exactly how many jobs all that translates into, but David Bourell, a mechanical engineer and materials scientist who runs the Laboratory for Freeform Fabrication at the University of Texas, Austin, says he hears of universities hiring more faculty who focus on 3D printing. "There is an upswing in the past few years as public and governmental interest in the field has increased," he says. "That's the topic they want to hire in." In part, he says, the surge in interest is being driven by the expiration of the founding patents for 3D-printing technologies, meaning that it is now less expensive for companies who want to get involved in the field.

#### VALUE ADDED

For his part, Vidimče took an idea from computer-graphics rendering and used it to create OpenFab, computer-aided design software for building an object from more than one material. A computer model describing the 3D shape of an object, as well as the specific areas where different materials go, would be so large that it could halt the printing process. So instead of trying to model the whole object at once, Vidimče's programme breaks it up into small sections, and provides the printer with a recipe for what to do in each section. That is the same way that graphics software renders complex images in a video game, treating them as a series of small problems instead of one large one.

At 3D Systems, Mehdi Mojdeh, director of 3D printing and a technical fellow, says that much of the company's research is aimed at improving the speed and accuracy of the process. Although industry has been using the



- 3D Systems in Rock Hill, South Carolina, offers internships at various locations, including New York, Los Angeles and Boston, for people thinking about pursuing research in 3D printing to get some first-hand experience with the machines. <http://www.3dsystems.com>
- Many universities have 3D printers in one research lab or other. And hackerspaces, which provide the public with various types of equipment to build things, usually have one, and will often offer training in how to use it. <http://hackerspaces.org/wiki>
- The website 'Rapid Today' provides a list of degree programmes that include 3D printing. [http://www.rapiddtoday.com/get\\_prototyping\\_education.html](http://www.rapiddtoday.com/get_prototyping_education.html)
- The online *Rapid Prototyping Journal* gives an entry into the

technology for a while to design and prototype new products, "we are trying to push 3D printing more into a manufacturing and production environment," he says.

General Electric (GE) in Fairfield, Connecticut, is increasingly using the technology for building parts that go into its products, from refrigerators to jet engines. The company has more than 500 employees working directly on 3D printing, and Stephan Biller, GE's chief manufacturing scientist, says that this is likely to increase. "There's no doubt about it, additive manufacturing is going to change GE and it's going to change manufacturing as a whole," Biller says. "I don't think people will have trouble finding a job in this area."

One of the greatest needs, Mojdeh says, is for researchers who focus on the properties of materials. Companies would like to expand the range of material properties such as strength, hardness, conductivity and so on, that are available. The wider the range of properties, the more types of objects that can be built, and the more functions such objects can have. Another key need is for scientists who work on an ultimate goal of the industry: multi-material printing, or the building of devices made of different substances — say, a ceramic engine part with metal circuitry built in. Very few products, after all, consist of only a single material, but today's 3D machines can print with only two different polymers at most.

Those goals mean that the industry needs both researchers who can develop materials with desirable characteristics, and those that can make the various printing technologies

## CASE STUDY

### Learning about 3D printing

literature on current and past research in 3D printing.

<http://www.emeraldinsight.com>

- Students could consider attending conferences to hear reports of current research and to talk to people in the field.

- The Additive Manufacturing and 3D Printing International Conference in Nottingham, UK, on 7–11 July.

<http://www.am-conference.com/>

- The 25th Annual International Solid Freeform Fabrication Symposium in Austin, Texas, on 4–6 August.

<http://sffsymposium.engr.utexas.edu/>

- The Inside 3D Printing Conference and Expo is a business-to-business trade show with several shows a year around the globe.

<http://www.mediabistro.com/inside3dprinting/>

- The Rapid Prototyping Calendar lists a variety of upcoming conferences.

<http://www.additive3d.com/conf.htm> N.S.



Jewellery makers benefit from 3D printing.

STEFANO TINTI/SHUTTERSTOCK

3D SYSTEMS

on design, multi-material printing and polymers. Loughborough University will deal with hybrid printing technologies. The University of Liverpool will focus on research into metals, and Newcastle University will specialize in additive manufacturing for biomedical uses.

### GOING GLOBAL

Last September, Nanyang Technological University in Singapore opened the NTU Additive Manufacturing Centre. The centre offers master's degrees in precision engineering, mechanical engineering and manufacturing systems and engineering, all with a specialization in additive manufacturing, as well as a PhD in mechanical engineering with a topic in additive manufacturing. It is also providing internships to students from around the world.

The creation of the centre has led to postdoc and faculty positions in several disciplines, including

materials science, mechanical engineering, chemical engineering and biomedical engineering, says Chua Chee Kai, who heads it. He says it is too early to predict how many jobs related to 3D printing there might be in the business world in general, because the technology is in the early stages of adoption. "We do, however,

firmly believe that these are high-value jobs that will change the landscape of that particular business or sector," he says. And as the field grows, he predicts, "we will need not just engineers, but also computer experts, mathematicians, software engineers, material scientists, quality experts, system-solution providers and many more to sustain the economic ecosystem of 3D printing."

Bourell says that even institutions without formal programmes usually have some research going on. "You can pick almost any university and they have some kind of activity these days," he says. "They have at least one person dabbling." He expects the field to evolve and expand rapidly enough over the next 5 to 10 years for there to be considerable demand for people with master's- and PhD-level education. "We're right on the edge of the wave," Bourell says. "Now it's time to jump in." ■

**Neil Savage** is a freelance writer in Lowell, Massachusetts.



**"If you continually develop the materials, then processes will have to change."**

Christopher Tuck

### RESEARCH EFFICIENCY

## Time wasted

US scientists are spending 42% of their time on bureaucratic chores, according to a US National Science Board (NSB) report. The NSB named financial and personnel reporting and over-detailed preliminary grant proposals as common complaints. Arthur Bienenstock, chair of the NSB task force that authored the report, says that the need to submit a detailed budget in the first round of a grant proposal, for example, is 'nonsensical'. The NSB found that an over-regulation culture is overwhelming US scientists, and recommends limiting proposal requirements to those essential for evaluating merit; keeping reporting focused on outcomes; and automating payroll certification.

### AWARDS

## Postdoc prizes

Three science-award recipients based in New York City have pledged US\$3 million of their prize money to set up an endowment to fund awards for postdoctoral researchers. Charles Sawyers of Memorial Sloan Kettering Cancer Center, Cori Bargmann of Rockefeller University and Lewis Cantley of Weill Cornell Medical College last year each won \$3-million 'Breakthrough' prizes. The new Tri-Institutional Breakout Awards for Junior Investigators will offer three to six \$25,000 awards per year. The endowment founders say they are donating part of their prizes because they believe that postdocs will benefit more from the support. "For me, a prize at that stage of my career would have been really helpful," says Bargmann, who adds that postdocs do much of the most creative work in science. Inaugural winners will be announced by the end of the year.

### MULTIPLE DISCIPLINES

## Converging futures

Exciting future research opportunities will arise where disciplines converge — but government funding and academic structures are ill prepared to take advantage of them, says a report from the US National Research Council. Report committee chairman Joseph DeSimone says that this convergence will require scientists to understand the language of multiple disciplines and sectors, and calls 3D printing (see page 521) a 'wonderful example', as it depends on so many different disciplines.