How 3D printing can lead to more sustainable plastics

An ASU professor and his collaborators are pursuing innovative approaches to make polymer materials more sustainable

By Jenny Green, ASU News
October 28, 2026

Products made from plastics, foams and other polymers are integral to modern life — found in everything from homes, cars and furniture to airplanes, ships, machinery and computers.

Worldwide, more than 660 billion pounds of polymers are produced each year. Yet in the United States, only about 10% of these materials are recycled, leaving enormous quantities of waste and posing a growing environmental challenge.

The scale of the problem is staggering — but so is the potential impact of a solution.

Tim Long, a professor in Arizona State University's School of Molecular Sciences and director of the ASU Biodesign Center for Sustainable Macromolecular Materials and Manufacturing, is working to address this challenge.

By bringing together expertise in chemistry, chemical engineering, health sciences and mechanical engineering, Long and his collaborators are pursuing innovative approaches — such as 3D printing — to make polymer materials more sustainable.

Here, he talks about his work.

Note: Answers have been edited for length and/or clarity.

Question: How can we address the negative consequences of plastics in our environment?

Answer: One straightforward approach is to use less plastic. With 3D printing, we can rethink the way we design structures. We call these different designs form factors. For example, instead of making a solid object, we might create a carefully engineered foam- or lattice-like structure. By precisely designing that structure, we can achieve properties that are even better than those of a solid material while using less material overall.

Our laboratory is very actively pursuing this research frontier, particularly with light-based 3D printing. We shine light into specially designed polymer materials to create three-dimensional structures. There are several different approaches to 3D printing, but what makes additive manufacturing so exciting is that it allows us to place material exactly where we want it. We are able to construct unprecedented form factors of polymer products, even at the micron dimension, 1/100th the diameter of a human hair!

Historically, manufacturing has often relied on subtractive processes, in which material is removed from a larger piece, generating waste. This waste is often called scrap. Additive manufacturing turns that approach around: We build an object by adding material where it is needed. That creates opportunities to reduce waste and rethink how products are designed.

Q: How is your laboratory advancing 3D-printing technology?

A: One particularly exciting development is our ability to conduct light-based 3D printing at elevated temperatures. Historically, this type of printing has largely been performed at room temperature. Here at the Biodesign Institute, we have a printer that can be heated to more than 100 degrees Celsius. Our high temperature printer is the first one located in the U.S.

That capability makes a significant difference. It allows us to investigate photochemistry at elevated temperatures, opening up a wealth of fundamental scientific questions. At the same time, it enables us to manufacture materials and structures that have not previously been possible. We are combining fundamental science with entirely new manufacturing possibilities.

Q: One of your research topics is 3D printing materials for satellites. What are you working on in that area?

A: This is one of the projects that really keeps me awake at night. The number of satellites in low Earth orbit is expected to increase dramatically over the next two decades, and many satellites contain plastics. We need to ask ourselves what we have learned about sustainability here on Earth and how we can apply those lessons in space.

Satellites do not last forever. Eventually, many reenter Earth's atmosphere and burn up. Their materials can generate metallic nanoparticles or potentially harmful chemical compounds. We need to consider not only the environmental consequences of their eventual reentry but also the possibility of damage from falling debris.

One of our major questions is: How can we develop safer, more sustainable materials for satellites? This is an immense challenge. We are not simply designing packaging for a consumer product; we are developing materials for the extreme conditions of outer space. These materials must withstand reactive environments and high temperatures. Sustainability is essential, but so is performance. We need materials that can do both.

Our laboratory is working with some of the highest-temperature polymers available. These materials can remain stable at temperatures approaching 500 C, or more than 900 F. We are developing ways to print them into three-dimensional structures capable of withstanding demanding environments.

One example is a class of materials called polyimides. If you have visited the National Air and Space Museum in Washington, D.C., you may have seen the orange film used to wrap the lunar

module. Imagine taking that same type of material and printing an entire structure from it rather than using it only as a protective film. Could we imagine printing the entire lunar module? That is the kind of possibility we are pursuing.

Q: Beyond outer space, what other harsh environments are you studying?

A: Fire is another important example. We have a major emphasis on developing flame-resistant materials. How can we prevent plastics from burning? And if a material does burn, how can we reduce the release of toxic gases?

Working with the Office of Naval Research, we are investigating materials for ships that could be safer, less toxic and less harmful to the human body. That is another important dimension of sustainability. It is not just about what happens to a material at the end of its life; it is also about protecting people and the environment while that material is being used.

Q: How are you working with industry to develop more sustainable materials?

A: Our research is increasingly encouraging us to think about sustainability across the entire supply chain. For example, we have a grant with Cargill, a major company with a presence here in the Phoenix area. Cargill produces oils used in many applications, including food production. We are exploring how these oils can be used in innovative ways to create high-performance plastics.

One particularly interesting application is semiconductor manufacturing. We are developing materials for what is known as electronic packaging. The idea that an oil derived from fatty acids could contribute to materials used in computer technology may require a little imagination, but it is possible. We are developing materials with properties that could make them well suited to these applications.

Q: What other advanced materials are you developing?

A: We also have a project with the U.S. Air Force focused on 3D-printed ceramics and related materials for extreme-temperature applications. These materials can withstand temperatures approaching 2,000 C. That is especially important for hypersonic technologies, where objects travel at extremely high speeds and experience enormous frictional heating.

In these environments, conventional organic materials are often not suitable. We are investigating specialized materials, including preceramic polymers, that can be used to produce high-temperature ceramics. It is a more complex area of research, but it offers exciting opportunities for applications where thermal performance is critical.

Q: Microplastics are another major environmental concern. How is your laboratory addressing that issue?

A: We are very active in microplastics research. There is considerable public concern about microplastics, and we believe that sound scientific understanding is essential to addressing it.

We are developing analytical tools that allow us to generate and characterize microplastics in controlled ways. This helps us understand how they form and what happens to them under different conditions. We are also working with Professor Alexandra Ros, in the School of Molecular Sciences, to investigate how microplastics are generated and what their fate may be in simulated

physiological fluids.

Another important goal is to develop materials that do not generate microplastics, or that at least have a reduced tendency to produce them.

Understanding how microplastics form, how they behave and how we might prevent or reduce their formation is an important part of sustainability.

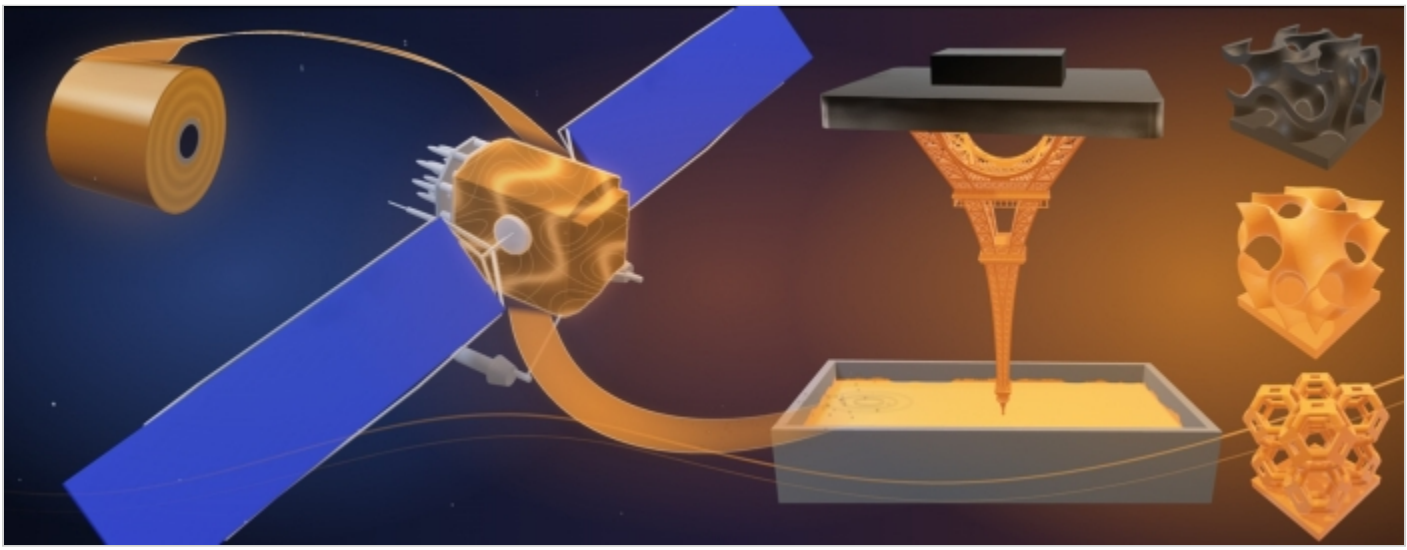
This story originally appeared on ASU News.

Main image



More than 660 billion pounds of polymers, which go into plastic pellets like the ones seen above, are produced each year. Yet in the United States, only about 10% of these materials are recycled. An ASU professor and his collaborators are pursuing innovative approaches — such as 3D printing — to make polymer materials more sustainable. Photo by Andy DeLisle/ASU Knowledge Enterprise

Text image(s)



Graphic depicting different 3D-printing possibilities. Courtesy of Garvit Nayyar, doctoral student in Professor Tim Long's research group



Professor Tim Long (far right) and his research group outside the Biodesign Institute on the Tempe campus. Courtesy photo