MATERIALS SCIENCE

Composite printer paves way for custom robots

Four-in-one device mixes materials with speed and precision.

BY MARK ZASTROW

A prototype 3D printer has for the first time combined several printing methods to enable researchers to produce devices from multiple materials in a single print run. So far, the machine has created basic electronic devices, but the technology brings materials scientists a step closer to their goal of printing complex equipment such as robots or smartphones.

The printer was presented at a meeting of the American Chemical Society in New Orleans, Louisiana, on 21 March.

"This is a remarkable technological advance and a great leap for the field of 3D printing," says Xuanhe Zhao, a materials scientist at the Massachusetts Institute of Technology in Cambridge, who was not involved in the work.

The most common 3D printers heat a plastic filament and lay it down in repeated lines, building a layered structure from the bottom up. This is the technique used in inexpensive consumer models. Several other 3D-printing methods have also emerged in recent years; these include spraying fine streams of aerosols, printing with liquid resin that is then cured to form a flexible polymer, laying down thin layers of ink that are dried and hardened when exposed to light, and even printing with ink that contains conductive nanoparticles, to produce wires and circuits.

"Each printing technology has its own limitations," says Jerry Qi, a materials scientist at the Georgia Institute of Technology in Atlanta, who led the design of the multimaterial printer. "We put four 3D-printing technologies under one platform."

"This is a remarkable technological advance and a great leap for the field."

Although current 3D printers can already produce electronic parts and devices made of multiple materials, if a structure requires more than one printing method a different machine is required for each. But moving an object from one printer to another is usually impractical for the micrometre-level precision that is required in 3D printing, and is inefficient if several materials are used in a single layer, says Qi.

His team's multimaterial printer has printheads — the nozzles that produce the material — for each of the four techniques on a single printing platform. Each has its own software, lights for curing the materials, and a moving platform and robotic arms that can pick up and place components. This allows the printheads to work together to build single layers with a range of materials. "It is a very smart solution to this challenge," says Zhou.

Qi and his team have used the printer to embed a light-emitting diode inside a plastic case, printing the inner circuitry at the same time as the outer enclosure. They have also printed a layer of conductive ink inside a rubbery material that can stretch while delivering a current, demonstrating its potential for flexible electronics.

The printer has excited researchers in the field. "We just had a conversation where we were dreaming of that kind of machine," says Geoff Spinks, a materials engineer at the University of Wollongong in Australia. Such stretchable electronics could be used in compact soft robots, providing flexibility that is impossible using current methods of embedding wires into a device, he says.

The machine was funded mostly by the US Air Force and cost roughly US$350,000 to build, says Qi. He thinks the printer's first customers will be aerospace companies that will use it to design circuitry for avionics, where printing antennas directly could enable rapid prototyping of avionic devices. Qi estimates the printer would sell for about $1 million.

Spinks says this is only the beginning for multimaterial printers. He expects devices with expanded capabilities will soon become available: "I'd imagine in the near future we might have 16 different types of printheads." ■

ENVIRONMENT

Forecasting efforts target harmful plankton blooms

Ocean scientists seek automated system to predict the growth of tiny marine denizens.

BY JEFF TOLLEFSON

Massive blooms of a marine organism called *Noctiluca scintillans* are currently threatening fisheries, tourism and desalination plants in the Arabian Sea. But scientists are developing forecasting models that could help Oman and other countries in the region to predict when conditions seem ripe for a boom in these single-celled creatures, so that they can be better prepared.

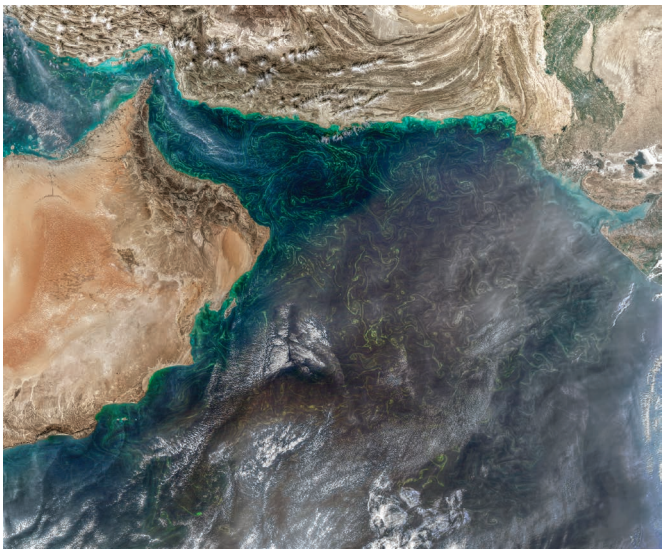
The goal is to produce a mostly automated system that works like a weather forecast. It would ingest data on atmospheric and ocean conditions, and kick out regular seven-day bloom forecasts — which would be available to businesses, governments and scientists.

Such a system could also help researchers to understand the spread of plankton blooms in the Arabian Sea and beyond in the decades to come, says Joaquim Goes, a biological oceanographer at the Lamont-Doherty Earth Observatory in Palisades, New York, and leader of the modelling project. The blooms might provide a short-term boost to some commercial fisheries, but marine biodiversity could ultimately decline if *Noctiluca* continues to grow and dominate the ecosystem, he says.

The project is one of several efforts around the world to develop models that can be used to understand and forecast harmful algal blooms. As early as this year, the US National Oceanic and Atmospheric Administration (NOAA) expects to launch its first

operational forecast for toxic plankton blooms in the Gulf of Maine using a similarly advanced model, says Richard Stumpf, a NOAA oceanographer in Silver Spring, Maryland.

Simulating, and then predicting, such blooms is difficult, Stumpf says, because researchers must understand not just local water chemistry and ocean circulation but also the behaviour of different plankton species.



AQUA/MODIS/GSFC/NASA

***Noctiluca* blooms (green swirls) in the Arabian Sea, as seen from space.**

BOOM AND BUST

A huge bloom in the Arabian Sea that began last November is only now winding down. At its peak in January, it covered an area three times the size of Texas. "*Noctiluca* is completely overwhelming the system," says Goes.

Goes and his team spent five weeks in Oman in January and February this year collecting samples and talking to local fishermen, as well as industry and government officials. They discussed the forecasting system and the kind of bloom-prediction information community members would need.

The team's current forecasting model is promising, and the researchers hope to improve its resolution and to incorporate information on *Noctiluca*'s tricky biology.

This minute organism has both plant and animal characteristics. It is a predator that thrives in the low-oxygen waters that have become more common in the region (H. R. Gomes *et al. Nature Commun.* **5,** 4862; 2014). But *Noctiluca* also has a symbiotic relationship with algae that live inside the cells. These algae contain the green pigment chlorophyll, which sensors on satellites can monitor from space, enabling researchers to track the blooms.

A GROWING PROBLEM

It's unclear why major *Noctiluca* blooms now occur in oceans around the world, including off the coasts of India, Thailand and Indonesia. Researchers suspect that the release of raw sewage, which provides nutrients, and global warming might have roles.

The right conditions can stimulate *Noctiluca* blooms so thick that when they die, the decomposing bodies suck most of the oxygen out of the seawater. In years past, the bloom's expanding low-oxygen zone drove sardines onto some beaches in Oman; aquaculture farms have also been affected.

This year, desalination plants had to scale back their activities to prevent *Noctiluca* from physically clogging their systems.

The current model devised by Goes and his team for the Indian Ocean has a resolution of 3.5 kilometres. It's able to forecast the bloom potential of two types each of plant and animal plankton. The model reproduces the large-scale behaviour of the current bloom in the Arabian Sea fairly well, but it's not yet detailed enough to produce a useful forecast for a local shrimp farm or a desalination plant, says Sergio deRada, an ocean modeller at the Naval Research Laboratory at the Stennis Space Center in Mississippi.

The next step is to boost resolution to 1 kilometre or even 500 metres, and to represent *Noctiluca* itself in the model. The problem, says deRada, is that *Noctiluca*'s behaviour is more complex than that of the plankton currently included in the model. "That's why modelling it is going to be tough." ■

MEDICINE

Reduced-calorie diet shows signs of slowing ageing

Restricting food intake dials down people's metabolism in clinical trial.

BY ALISON ABBOTT

A study of people who reduced the calories they consumed has found the strongest evidence yet that such restrictions can slow down human metabolism. The results raise hopes that a low-calorie lifestyle — or treatments that mimic the biological effects of restricted eating — could prolong health in old age, and even extend life.

Past work in many short-lived animals, including worms, flies and mice, has shown that calorie restrictions reduce metabolism and extend lifespan. But experiments in longer-living humans and other primates are more difficult to conduct and have not yet drawn clear conclusions.

The study was part of the multi-centre trial called CALERIE (Comprehensive Assessment of Long term Effects of Reducing Intake of Energy), sponsored by the US National Institutes of Health. The randomized, controlled trial tested the effects of 2 years of caloric restriction on metabolism in more than 200 healthy, non-obese adults.

"The CALERIE trial has been important in addressing the question of whether the pace of ageing can be altered in humans," says Rozalyn Anderson, who studies ageing at the University of Wisconsin–Madison. She leads one of two large, independent studies on calorie restriction in rhesus monkeys. "This new report provides the most robust evidence to date that everything we have learnt in other animals can be applied to ourselves."

Published on 22 March in *Cell Metabolism*, the latest study looked at 53 CALERIE participants who had been recruited at the Pennington Biomedical Research Center in Baton Rouge, Louisiana (L. M. Redman *et al. Cell Metab.* http://doi.org/cmrx; 2018). This