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A Conversation with Tomás Palacios

Katherine Bourzac

The electrical engineer shares his vision of putting electronics everywhere.

In recent years, the family of two-dimensional materials has expanded from the purely carbon graphene to include almost 1,000 materials that exist—or are predicted to exist—in an atomically thin form. These 2-D materials are flexible and transparent, and their unusual properties make researchers eager to apply them in electronic devices. Electrical engineer Tomás Palacios of the Massachusetts Institute of Technology believes ultrathin materials will allow engineers to completely reimagine what electronics look like and where they can go—allowing electronics to be placed almost anywhere and everywhere. He described his vision to Katherine Bourzac.

Courtesy of Tomás Palacios

Can you tell me about your concept for ubiquitous electronics?

What my group is trying to do is find applications for these truly amazing 2-D materials. We strongly believe that we should be able to change the form factor of electronics, allowing us to bring electronics to completely different objects than what we have been used to so far.

One way to bring us closer to the vision of ubiquitous electronics is to make electronic systems so large that we can wrap entire buildings with them. We are now starting to print electronics in the same way that we can print newspapers, so we can think of covering everything with smart materials. A different approach to ubiquitous electronics is to make these microsystems so tiny that we can have them everywhere and not even realize they are there. It's about embedding functionality and intelligence in just about every object that we have.

How might you embed functionality into a building or another large object?

We modified a 3-D printer in order to be able to print both structural materials, like polymers, and electronic materials based on graphene and other 2-D materials. For example, we worked with NASA to print the body of a small unmanned aerial vehicle and embed it with sensors in order to be able to monitor its structural properties and mechanical strain.

What about going small?

With conventional electronics, it's very difficult to find anything smaller than maybe one cubic millimeter. But nature is able to build extremely complex microsystems with a volume that is orders of magnitude smaller than that. Every single one of our cells is an amazing microsystem that I would argue is a lot more complex and interesting than many of the electronic microsystems we've made so far. So a couple years ago we started a large effort to try to demonstrate what we call synthetic cells, or syncells, based on 2-D materials. They are the only materials we know that are inherently flexible, transparent, and multifunctional, just like biological cells.

How do you make them?

The idea is to fabricate simple building blocks made of 2-D materials on a silicon wafer. One building block could

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be an LED transmitter or a solar cell energy harvester. Another could be chemical sensors of different kinds. Then you detach these building blocks from the wafer and have them in solution. To increase the density of our structures, we are working with Peng Yin's group at Harvard University. They are developing ways to use DNA to fold the 2-D materials and lock them in place.

The final goal of our research is to be able to develop artificial organelles with specific functionality that you could combine in arbitrary ways to make different types of syncells. For one syncell you take a few chemical sensors, and you combine that with memory and an LED communication building block. Then you wrap everything with a graphene membrane to hold it together. The goal is to demonstrate microsystems smaller than anything anyone has fabricated before with conventional silicon.

Once you have these tiny syncells floating in solution, you can start thinking about how to make the syncells interact with each other. How might you combine syncells of slightly different properties to build more complex microsystems? Or, how might you embed them in materials like asphalt, plastic, or paint in order to bring them to every object around us?

Your ideas about electronics are very imaginative. Where do you get your ideas?

I'm at a university so I am paid to come up with ideas that, although they may seem crazy today, may become a reality in a few years. My time horizon is very different from the time horizon of companies that are expected to make money in the next quarter.

Katherine Bourzac is a freelance contributor to Chemical & Engineering News, the weekly newsmagazine of the American Chemical Society. Center Stage interviews are edited for length and clarity.

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