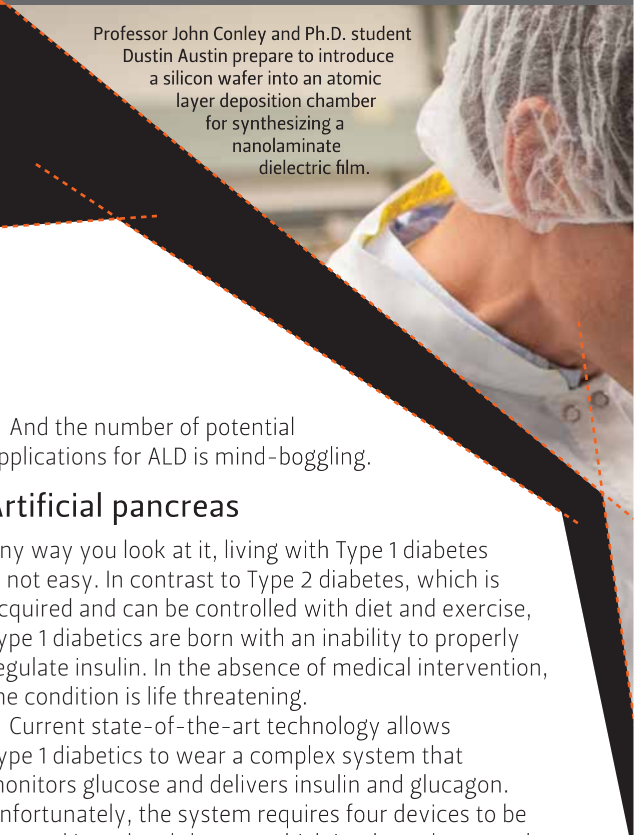
Thin film, fat potential

By Marie Oliver



Professor John Conley and Ph.D. student Dustin Austin prepare to introduce a silicon wafer into an atomic layer deposition chamber for synthesizing a nanolaminate dielectric film.

Professor John Conley has no problem finding materials science research projects to keep him excited and engaged in his work. His challenge is to choose among the numerous, diverse projects that call for attention.

Conley came to Oregon State after extensive industry and national lab experience with Dynamics Research Corp., the Jet Propulsion Laboratory, and Sharp Laboratories of America. He is now an Oregon Nanoscience and Microtechnologies Institute (ONAMI) Signature Faculty Fellow with the School of Electrical Engineering and Computer Science and the Materials Science graduate program and the co-director of the Materials Synthesis and Characterization Facility (MASC) at Oregon State.

Conley's signature area is a thin-film synthesis technique called atomic layer deposition (ALD). At present, he is contributing his expertise in ALD to at least seven collaborative projects, including (but not limited to) an artificial pancreas for Type 1 diabetics; MIM (metal-insulator-metal) structures with applicability to high-speed electronics, high-density capacitors, and neuromorphic computing; and improved coatings for aerogels, dental braces, and prosthetics.

Atomic layering 101

Atomic layer deposition is a process used to create thin films. It was invented in the 1960s, but experienced a resurgence in the late 1990s because of its potential for enabling the fabrication of ever-smaller, higher-density microelectronic devices.

ALD sequentially introduces vaporous chemicals — called precursors — in a meticulous and well-organized fashion. The precursors react one at a time and the film builds up in layers, allowing scientists precise control over thickness and composition at the atomic level. The technique enables scientists to uniformly coat uneven surfaces. "So if you need to coat a really narrow trench with highly conformal film, this is really the only technique that can do that," said Conley.

The use of specific precursors is determined by the desired application, and Conley has helped develop several of them. "We've developed several materials using this technique and improved the electrical properties for emerging electronic devices," he said. "Although my main focus is materials development and electronic device applications, I'm also interested in other applications of ALD."

And the number of potential applications for ALD is mind-boggling.

Artificial pancreas

Any way you look at it, living with Type 1 diabetes is not easy. In contrast to Type 2 diabetes, which is acquired and can be controlled with diet and exercise, Type 1 diabetics are born with an inability to properly regulate insulin. In the absence of medical intervention, the condition is life threatening.

Current state-of-the-art technology allows Type 1 diabetics to wear a complex system that monitors glucose and delivers insulin and glucagon. Unfortunately, the system requires four devices to be inserted into the abdomen, which is a lot to keep track of and can be uncomfortable for the wearer. These devices include two sensors (both to monitor glucose) and two pumps (one for insulin, one for glucagon).

A couple of years ago, Pacific Diabetes Technologies approached Conley because they wanted to improve the current technology by using flexible electronics to build an "artificial pancreas." They had heard about Conley's work through one of his former graduate students who had consulted for the company.

Conley's eyes light up when he relates this first conversation. "It sounded like a really neat project, much closer to everyday experience than a lot of the stuff I do — and kind of a stretch for me, outside of my usual area." He invited Greg Herman from the School of Chemical, Biological, and Environmental Engineering onto the research project, because of Herman's industry experience with flexible electronics.

The research team designed and built a single device that mimics an organic pancreas. "We're building these devices on flexible substrates that can bend around a narrow radius and still work," said Conley. "The device has multiple sensing locations that monitor glucose and will be designed to work with a dual chamber pump that delivers the correct hormone as needed. It will require only one insertion point in the patient instead of four, and presumably should be much more comfortable."

The artificial pancreas is almost ready for prime time. "They're getting ready to do animal studies on the devices we've made here at Oregon State, so it's really exciting," said Conley.

In addition to Pacific Diabetes Technologies, funding for the project comes from the Small Business Innovation Research Program at the National Institutes of Health, the Leona M. and Harry B. Helmsley Charitable Trust, and ONAMI.

And so much more!

Conventional microelectronic technology is beginning to approach fundamental limits, and Conley is participating in several interdisciplinary projects that are breaking new ground in the world of electronics. Devices based on quantum mechanical tunneling, in which an electron can instantly appear on the other side of a barrier, may provide a path to ultrafast applications. Conley's group is improving the performance of MIM tunnel diodes by using the ALD technique to deposit a nanolaminate insulator tunnel barrier that is engineered for precise control of charge flow and will help to reduce power usage and heat buildup.

Another project of this type involves the creation of a new type of solid-state memory called RRAM (resistive random access memory) that may replace flash memory for ultradense storage and has implications for neuromorphic computing.

Along different lines, he is working closely with John Simonsen in the College of Forestry to develop an ALD coating for aerogels that will enable wood scientists to develop organic/inorganic composites with improved properties and stability.

Conley's other projects — too many to mention here — are no less impressive. He is a new brand of engineer, crossing traditional research boundaries to apply his specialized knowledge in the development of a host of unique and innovative materials. **M!**