Blending electrical and chemical engineering

By Rachel Robertson | 04/27/2016

Graduate student Arturo Valdivia (right) and advisor Professor John Conley (left) use atomic layer deposition to deposit single-layer MoS_2 on a 6-inch substrate.

Making advances in two-dimensional semiconducting materials

was beyond the scope of what Arturo Valdivia could imagine for himself when he was growing up in the small town of Nyssa in Eastern Oregon. But his first research project as a graduate student was not only published in the *Journal of Vacuum Science & Technology A*, but it was selected as the "Editor's Pick" and was on the journal's most read list. The article was also featured in Beneath the AVS Surface, a news publication for the American Vacuum Society.

Valdivia, a Ph.D. student in material science in the College of Engineering at Oregon State University, probably would not have even pursued engineering had it not been for his high school advisor who took notice of his good grades.

"I liked sports and I thought I'd probably go into the military, because that's what most

people did from my town. But my advisor took a vested interest in my future and told me what courses to focus on to get into a community college and then to a university," Valdivia says.

Although he is a first-generation college student, he is following in the footsteps of his elder brother and sister who also graduated from college. Valdivia's advisor guided him to chemical engineering which he pursued at Oregon State as an undergraduate. And although he liked it, he discovered his passion when he was introduced to material science.

"Material science encompasses so many different aspects of engineering including chemical and electrical," Valdivia says. "What really drives me is a curiosity about many subjects, rather than just one."

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Valdivia received a scholarship from the Gates Foundation for graduate school, and he chose Oregon State to work with John F. Conley, Jr., professor of electrical and computer engineering. In his first year, he took on a project in collaboration with Doug Tweet at Sharp Labs of America that is now earning him some notoriety for implementing a technique that would make using single-layer MoS_2 (a two-dimensional metal material) a viable option for semiconductor device fabrication.

This technique could be pivotal in advancing applications such as low power electronics, transparent electronics, optoelectronics, catalysis, and energy harvesting. Single-layer MoS_2 had previously been achieved by the "Scotch tape" method which involves using a piece of Scotch tape to lift a thin layer of the deposited material and folding it on itself until a single layer is attained, but that is not a feasible method of fabrication.

"Researchers were using this method to show it can be done, but you're probably not going to fill a factory full of people using Scotch tape," Conley jokes. "The method we developed using atomic layer deposition demonstrates that wafer scale MoS_2 manufacturing is possible." Chemical vapor deposition is another technique that researchers are using, but it suffers from process instability and poor uniformity over large areas.

The project took a lot of work to even get started because their system had to be upgraded to handle the new material. Then, forging new ground meant a few mistakes were bound to happen along the way.

"You're pumping material that is like glue through a valve that is supposed to regulate small amounts, so there's a lot of learning painfully. For example, when you destroy the

valve because you didn't heat it right," Valdivia says.

Because he was often the one to make the repairs when needed, the experiences helped him learn the equipment inside and out. But it was not only technical knowledge and skills that he learned during the project.

"Being a graduate student is much different than being an undergraduate, you are expected to be independent and produce results, and that can be a huge leap," Valdivia says. "The biggest thing I got out of the project was how to work on my own, but it's still a learning process."

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