SEE, IT JUST LOOKS LIKE A pile of sand,” says post-doctoral researcher John Howard, pointing to the dirty-white chalk-like powder.

But this is no ordinary pile of sand. It came from a mix of ingredients that, when heated to 300 degrees Celsius, forms a new kind of material that, Howard says, could represent the next big leap in battery technology.

Howard is part of a team of UNLV researchers led by Yusheng Zhao, head of the university’s new energy materials lab. Fueled by $2.9 million in grant funding from the U.S. Department of Energy, Zhao, Howard, and their team are making advances in fundamental research about energy storage and transfer that could change what’s inside the batteries that power our personal gadgets and electric vehicles.

“We want battery-powered vehicles that go faster, go farther, and are safer,” Zhao says.
Their current focus involves development of a substance called lithium-rich antiperovskite, or LiRAP for short. (LiRAP is an electronically inverted form of “perovskite,” a crystal structure that’s abundant deep in the Earth’s mantle.) When synthesized in UNLV’s labs, LiRAP forms the basis of a new battery material Zhao and his team are working to develop. If their effort succeeds, it would lead to a new generation of batteries that could compete with current technology at a fraction of the cost while also providing added safety benefits.

To facilitate the ion transfer that generates energy, all batteries consist of three parts — a cathode, an anode, and an electrolyte in between. Zhao explains that current lithium-ion batteries contain a liquid electrolyte that is toxic, flammable, and leak-prone. For vehicles that rely on lithium-ion batteries, including airplanes and electric cars, leakage and combustion can be serious issues. Boeing’s highly touted new 787, for example, was initially plagued by batteries that could overheat and catch fire; similarly, electric vehicle manufacturers have faced concerns over fires resulting from routine car accidents.

Zhao’s battery material — the sand-like substance produced in his lab — creates a solid electrolyte that is impact-resistant and non-flammable, making it less dangerous and more environmentally friendly. Such innovations, Zhao says, are key to his lab’s success.

Recently, his team found a way to replace a typical carbon anode (the battery part indicated by a minus sign) with one made of lithium. The change increased the battery’s energy density, which could lead to more compact batteries able to provide more energy.

“This kind of discovery is why we do what we do,” Zhao says. “The unexpected is what makes research exciting.”

If the team’s work continues to go well, the resulting technology could lead to a new generation of batteries constructed as singular solid-state cells — cells that could safely and efficiently power devices ranging from phones and laptops to wearable electronics and electric cars.

Initial funding for Zhao’s battery lab came from the Advanced Research Projects Agency-Energy (ARPA-E), a federal initiative supporting important applied research related to energy. Competition for ARPA-E grants is intense, with about 1 percent of proposals receiving funds. Zhao’s $2.9 million grant, awarded in 2013, funds the lab at UNLV for three years and also facilitates collaboration with researchers at University of Texas and Los Alamos National Laboratory, where Zhao worked prior to joining the UNLV faculty.

Zhao credits his work at Los Alamos for laying the foundation for his current research at UNLV. He came to the university in 2010 to lead the High Pressure Science and Engineering Center. That work led to the research now being conducted at UNLV’s new energy materials laboratory, he says.

Zhao says research exploring materials to serve as solid-state electrolytes in batteries has been conducted for decades, but only recently was his team able to secure the resources necessary to take significant next steps.

“We are not just working on one battery component,” Zhao explains. “We are considering the battery as a whole. Our experiments serve as a bridge between fundamental science and practical applications.”

He cautions, however, that there is still much to explore. The team is currently working on crystal-structure manipulation, for example, to increase ionic conductivity and power capacity. They also are investigating the LiRAP electrolyte’s compatibility with different electrode materials, as well as exploring the LiRAP material’s functionality as a cathode (the plus-sign part of a battery).

“Dr. Zhao is conducting cutting-edge research in battery and battery-related technologies,” says Zachary Miles, associate vice president of economic development at UNLV. “The collaboration with ARPA-E has created some innovative opportunities for energy research with commercial promise, and we are enthusiastic about the future of this team’s work.”

— DAN MICHALSKI