SLAC NATIONAL ACCELERATOR LABORATORY

SLAC Science
Taking Materials to a Whole New Level

SLAC research is improving the performance of everyday materials and developing the deep understanding needed to create the materials of the future.

Creating a Clean Energy Future

Imagine a future where solar energy is cheaper than fossil fuels, affordable electric cars run hundreds of miles on a single charge and powerful new computer technologies leave today's gadgets in the dust. All these advances will require new materials, and SLAC scientists are helping make it happen.

SLAC's basic materials research is carried out by SIMES, the Stanford Institute for Materials and Energy Sciences at SLAC. It's jointly operated with Stanford and funded by the U.S. Department of Energy.

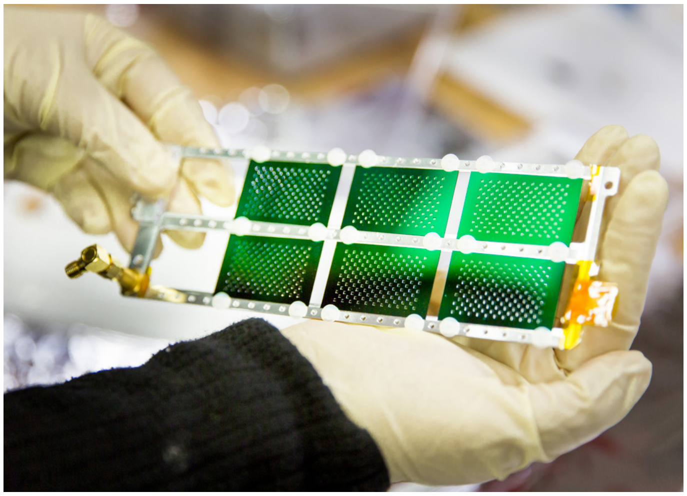
SIMES research runs the gamut – from fine-tuning processes for manufacturing solar cells to probing the fundamental properties of exotic new materials whose full potential will not be realized for years. The overarching goal is to create clean, renewable and affordable energy sources and technologies.

Teaming Up and Zooming In

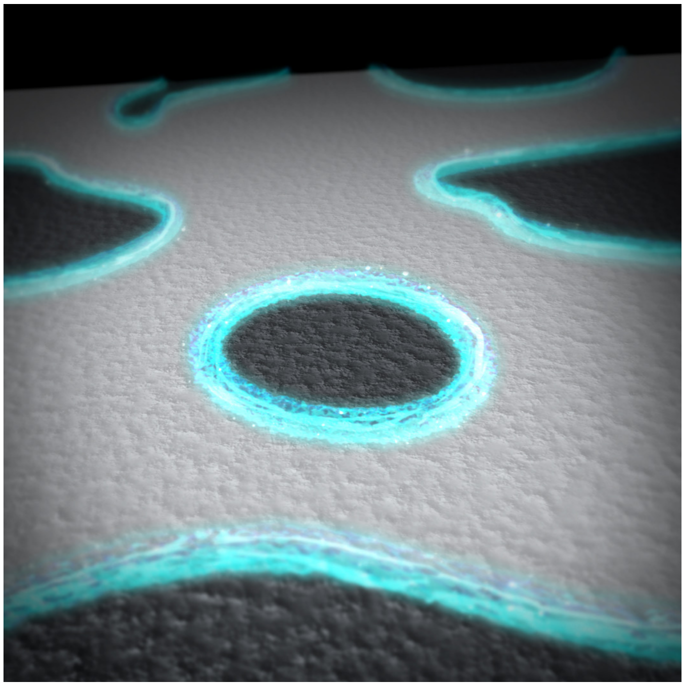
Working together allows SLAC and Stanford scientists to take full advantage of expertise and facilities on both campuses. They can use powerful X-ray beams from SLAC's Linac Coherent Light Source (LCLS) and Stanford Synchrotron Radiation Lightsource (SSRL) to analyze the atomic structure and chemical makeup of materials and see how they hold up in real-world operating conditions, whether in a factory, a car battery or your laptop.

Researchers from all over the world come to SSRL to solve practical problems – for instance, developing strong, lightweight alloys for airplane engines or fine-tuning catalysts to turn crude oil into gas more efficiently.

And LCLS's revolutionary X-ray laser technology takes materials science to a whole new level, zooming in on details never seen before. Scientists can watch the atoms in a material shift around in response to light or electrical current, or see tiny patches of magnetism emerge and change.



Above: A SLAC scientist holds samples of titanium alloys, like those used in aircraft engines and landing gear, being tested at SSRL. Below: An illustration shows electrical currents (blue) flowing on the surface of a topological insulator.



SLAC National Accelerator Laboratory
2575 Sand Hill Road
Menlo Park, CA 94025–7015

slac.stanford.edu

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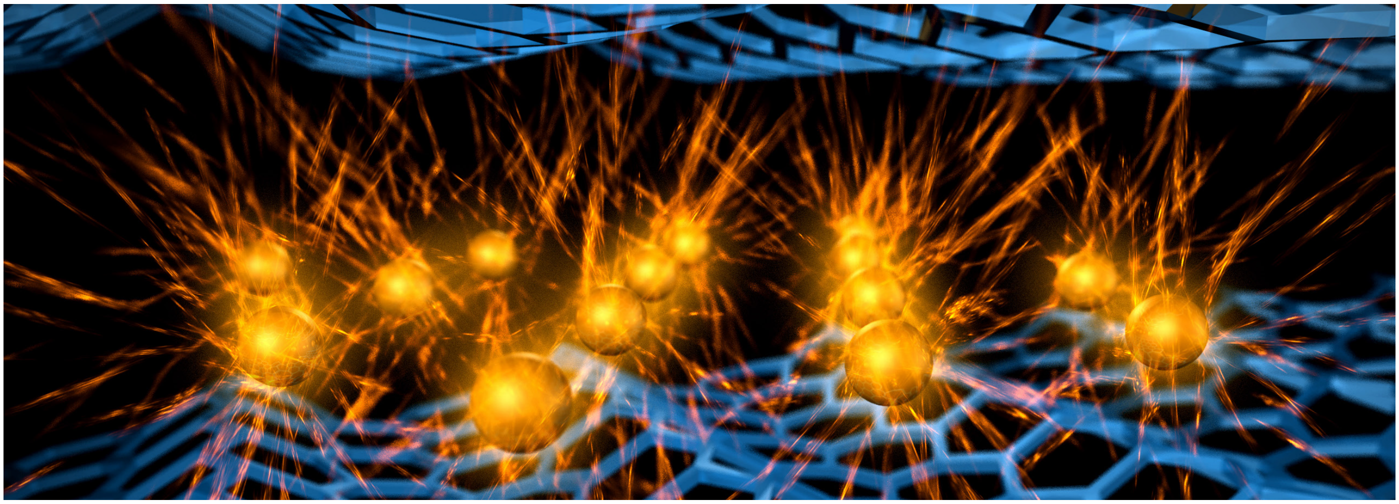


From Insight to Action

These basic studies bear fruit in many ways.

One example is diamondoids, tiny interlocking cages of carbon and hydrogen discovered in oil wells in 1932. After years of study, SLAC and Stanford scientists found that coating solar cells with a thin layer of these tiny diamonds lets them operate more efficiently at high temperatures – a technology that's now being commercialized.

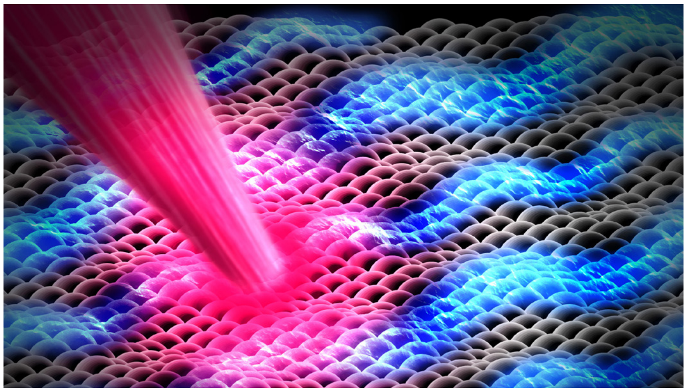
Another line of research on ways to protect battery electrodes from cracking and degrading during charging has led to high-performance, longer-lasting batteries now being used in millions of cell phones.

Materials Go Quantum

Some of the most exciting research involves so-called quantum materials with surprising, complex behavior. These quirky new traits may emerge when materials are made in layers just one atom thick, or at the interface where one material with just the right properties bumps up against another.

Room-temperature superconductors could revolutionize power transmission by carrying electricity over long distances with zero loss. SLAC and Stanford scientists are at the forefront of developing tools to study these novel superconductors, with the goal of raising their operating temperatures into a more practical range.

Topological insulators – materials that conduct electricity only on their surfaces – could enable a new type of computer memory based on "spintronics," which would use the spins of electrons rather than their charges to store information. SIMES scientists developed the theory that led to discovery of the first topological insulator and made the first direct images of currents flowing along its edges.



Top: Illustration of a SLAC experiment that investigated why sheets of graphene become superconducting when calcium atoms (orange) are added. Middle: SLAC scientists at an SSRL beamline used for materials science experiments. Bottom: An illustration shows a 3-atom-thick material wrinkling in response to a laser pulse in an ultrafast electron diffraction experiment at SLAC.

SLAC is operated by Stanford University for the U.S. Department of Energy Office of Science