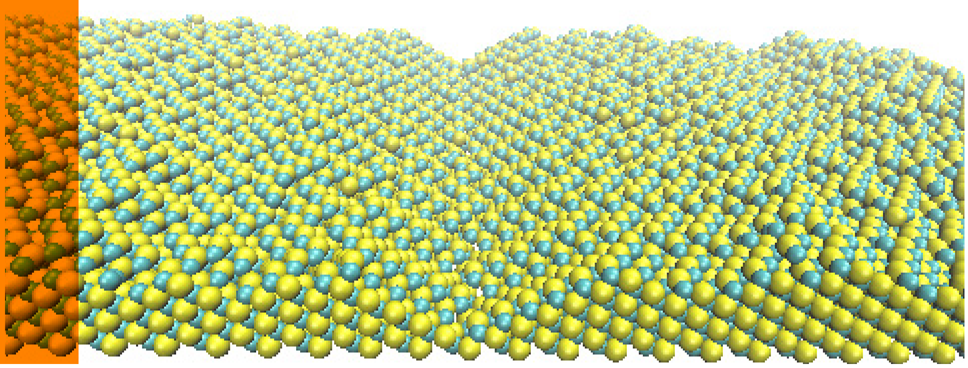
NANO DESIGN WORKS

Argonne NATIONAL LABORATORY

PREDICTIVE MODELING OF WIDE-BANDGAP SEMICONDUCTOR PROCESSING

Understanding some of nature's most promising materials



Simulation of epitaxial growth of a WBG semiconductor (SiC) on a non-traditional crystal orientation, predicting the emergence of a faceted texture on the materials surface. Simulations allow the exploration of growth conditions not commonly available in the lab.

CHALLENGE

Wide-bandgap semiconductors hold great promise for improving energy efficiency in applications such as power electronics that rely primarily on silicon devices for energy management. However, silicon's limited capability to withstand high voltages and to rapidly switch energy flows makes management difficult. Wide-bandgap semiconductors—such as gallium nitride—have been shown to outperform silicon by three orders of magnitude in this regard.

Rapidly incorporating these semiconductors into next-generation power systems requires predictive modeling. Besides understanding how these complex structures are grown, researchers also need to know their weaknesses and defects—and this requires understanding the structure of these materials at the nanoscale. Only then can industry exploit them for their enormous potential in not only power electronics but also in numerous other vital energy applications, such as grid management.

SOLUTION

An Argonne team led by Paul Fuoss is harnessing the power of the Argonne Leadership Computing Facility and Advanced Photon Source (APS) to develop the models vital to the adoption of these materials.

APS provides the brightest storage ring-generated X-ray beams in the Western Hemisphere, allowing researchers to watch these crystalline structures grow in environments as similar as possible to those in industry. This capability, coupled with Argonne's renowned expertise in modeling and simulation, is providing critical knowledge, assisting industry in harnessing the power of these novel materials, and pushing the envelope in energy management and efficiency.

BENEFITS

Wide-bandgap semiconductors have the potential to greatly impact the energy sector through:

- Higher frequency operation, resulting in greatly improved efficiency and reduction in package size and weight.
- The standing off of higher voltages, allowing for more flexible power management.
- A higher temperature operation, resulting in simplified thermal management and potentially higher reliability.
- High performance of devices, leading to reduced component counts and simpler manufacturing.

APPLICATIONS

Wide-bandgap semiconductors are of great interest to a number of stakeholders, including:

- The defense industry, which seeks reduced vulnerability via increased efficiency.
- The transportation industry, which needs high-performance, low-weight, high-reliability power systems.
- Electric utilities where high-efficiency DC-DC and DC-AC conversion will help integrate renewable energy sources into robust electric grids.

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U.S. DEPARTMENT OF ENERGY

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