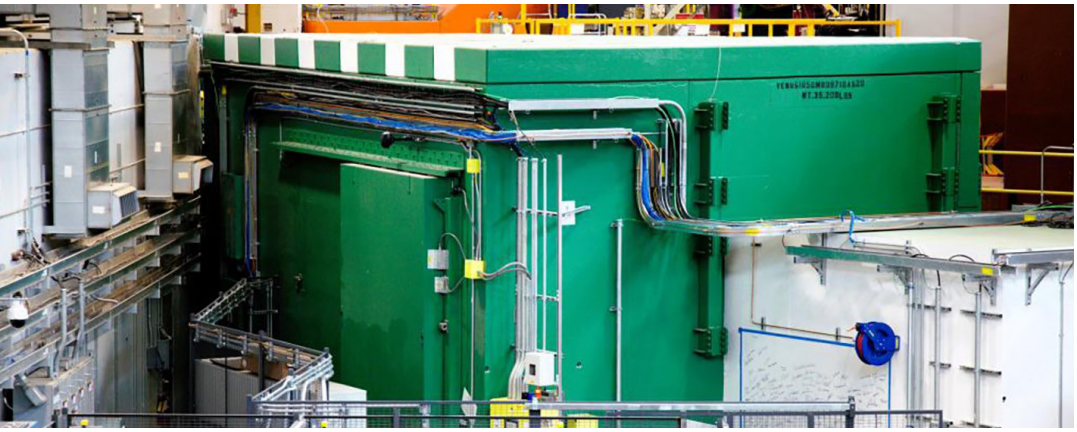
VENUS: Versatile Neutron Imaging Instrument



The **VENUS** imaging instrument is the most cutting-edge research platform of its kind in the United States. VENUS offers neutron imaging capabilities to provide insights into materials used in energy applications, additive manufacturing, nuclear fuels, biological systems, geosciences, even archeological artifacts, and many other applications.

Why neutrons?

Neutrons are non-destructive and can penetrate metals while being sensitive to light elements such as hydrogen or lithium. Neutron imaging is a research technique that provides images, called radiographs—similar to clinical X-rays—in which contrast is used to reveal the internal structure and dynamics of an object.

Optimized for basic and applied science

Built at the world-leading Spallation Neutron Source (SNS), VENUS leverages the unique time-of-flight capabilities enabled by the facility's pulsed-beam accelerator. The time-of-flight capability provides information on composition, temperature, stress, texture, phase transformations, and more—all in a single measurement. VENUS enables real-time investigations of materials and mechanical behaviors while in operation and under extreme conditions.

Accelerating opportunities

Major manufacturers and industry leaders that have benefited from the current neutron imaging capabilities at Oak Ridge Lab's High Flux Isotope Reactor include Ford, GM, Chrysler, Toyota, United Technologies Research Center, Honeywell, Cummins Engines, Detroit Diesel, Mack, Delphi, Navistar, PACCAR, John Deere, Caterpillar, Volvo, GE, Whirlpool, DuPont, Thermacore, Mars, and Bush. VENUS's addition to SNS will allow for more industry partnerships and opportunities.

Aerial view of the Spallation Neutron Source.

Contact information:

Hassina Bilheux
VENUS Instrument Scientist
bilheuxhn@ornl.gov
neutrons.ornl.gov/venus

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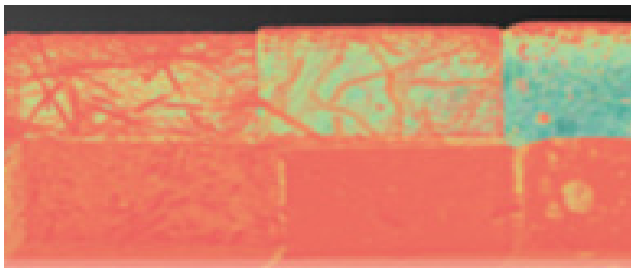
Additive manufacturing

VENUS provides truly unique insights into industrial 3D-printed materials. Prototype experiments at the SNS facility have already demonstrated VENUS's ability to reveal microstructural disparities between different additively manufactured materials using neutrons of different wavelengths. Such insights will help improve manufacturing methods to develop stronger materials.

Different textures can be seen with different spectral wavelengths. Differences in grain orientations in additively manufactured materials using a conventional polychromatic neutron beam (a), compared to neutron radiographs produced using different neutron wavelengths (b, c).



Neutron imaging data showing microstructures of conventional and ultrahigh-performance concretes exposed to different temperatures with induced phase transformations.

Advanced materials

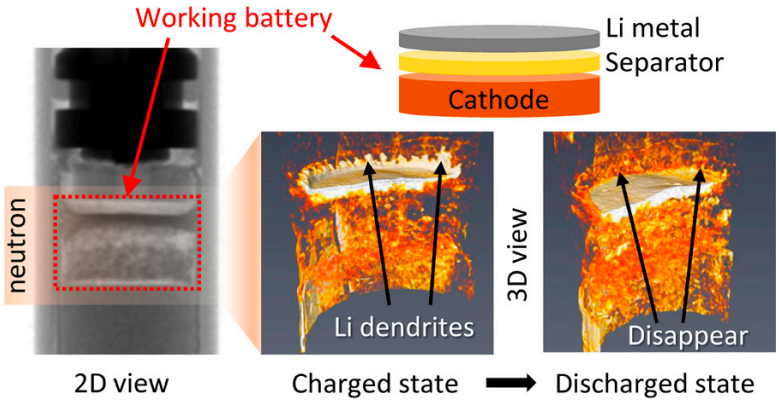
VENUS can be used to evaluate materials at different stages of manufacturing to improve process design and prevent waste. Neutron imaging is useful in understanding the composition of alloys and the impact of impurities on a material's properties. This is essential, for example, in developing stronger carbon fiber, concrete, and composite materials.

Energy storage

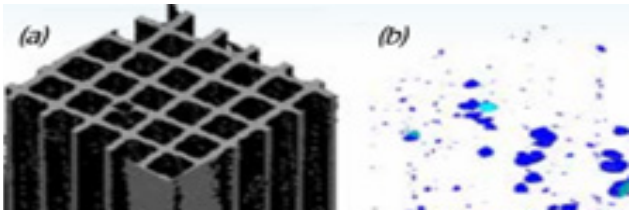
Optimizing lithium-ion transport is a key to improving the power, capacity, and lifetime of batteries.

"With its predicted higher spatial resolution, VENUS [will] deliver the capability to quickly construct 3D maps that not only show the lithium distribution inside of a real battery electrode at a fixed state of charge, but the higher flux available at the SNS could also enable studies of dynamic behavior in batteries and other vehicle components."

—Andy Drews, Ford Research & Advanced Engineering



Neutron imaging scan of lithium distribution in a control battery.



Neutron imaging scan comparing diesel particulate filter (a) with the particulate (b) inside the filter that help to better understand how particulate matter moves during engine cycles.

Transportation

VENUS helps predict system behaviors and maximizes energy efficiency of next-generation vehicles, for example, the development of better spray models and fuel injection systems. VENUS allows internal viewing of diesel exhaust systems and enables advanced in-situ engine experiments and diagnostic research.

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