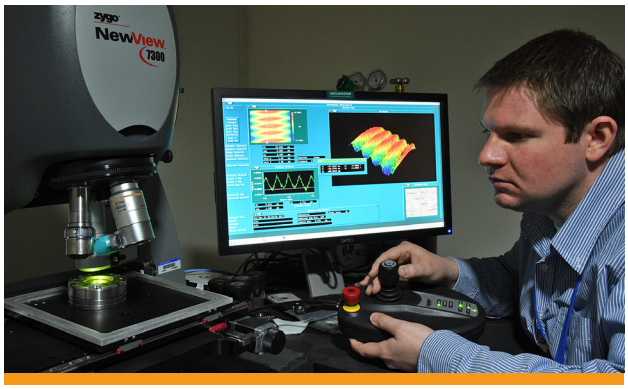
Modernizing the nation's stockpile:

Plutonium Surface Science Lab



Using the first-ever scanning probe microscope dedicated to surface studies of plutonium, researchers in the Plutonium Surface Science Laboratory at Los Alamos recently produced 3D surface topography images with nanometer-scale resolution. The work yielded unparalleled images that aid both macroscopic signatures for nuclear weapons engineering and atomic-scale plutonium investigations that validate theoretical modeling codes.

Los Alamos National Laboratory is the Department of Energy's premier nuclear weapons lab and the nation's Plutonium R&D Center of Excellence. The Lab combines decades of expertise with one-of-a-kind tools to ensure the safety and stability of the nation's nuclear stockpile.

Understanding the chemistry and physics of certain actinides is a key priority for both the DOE and Los Alamos. The Plutonium Surface Science Lab (SSL) provides researchers with unique instruments that reveal new details about phenomena at work in actinide materials, especially plutonium, a fissile element used in nuclear weapon pits.

The SSL's suite of tools, developed with the expertise of Los Alamos' Materials Science and Technology Division members and their collaborators, is designed to enable science essential to stockpile stewardship, plutonium processing and aging, nuclear forensics, and fundamental understanding of radioactive elements. Many of the instruments at the SSL are the only ones in the world dedicated to plutonium, and all are jointly located at a facility within Los Alamos.

On the reverse page, take a closer look at these researchers' tools and the discoveries that have resulted from their use—discoveries that make the world a safer, more stable place.

Materials For the Future

Deep dive: the tools

Researchers use the Plutonium Surface Science Lab's instruments to probe surface structure before and after exposure to various atmospheric gases.

Ultrahigh vacuum scanning tunneling microscope

The Materials Science and Technology team conducts topographic imaging at an atomic resolution with this tool, measuring the local density of occupied and unoccupied states and enabling sputtering, annealing, and gas dosing for sample preparation and modification. The system houses an Omicron variable temperature scanning tunneling microscope (STM) inside an ultrahigh vacuum, dual-chamber multiprobe. It was used to take the first-ever STM images and scanning tunneling spectroscopy spectra of plutonium surfaces and has since supported a Los Alamos project examining catalysis on plutonium surfaces. Researchers are using this tool to investigate a potential new plutonium topological insulator.

Glovebox atomic force microscope

A Bruker MultiMode 8 housed in an inert atmosphere glovebox provides 3D surface maps with topographical information using spatial scales ranging from tens of nanometers to tens of microns. With versatile, easily reconfigured imaging modalities, this instrument can map tip-sample interactions such as surface potential, magnetic force, and electrical conductivity. It also produces quantitative mechanical information, such as elastic modulus, deformation, and adhesion, that enables scientists to map surface stresses on plutonium coupons. The Materials Science and Technology team has used the glovebox atomic force microscope to support a National Nuclear Security Administration Science Campaign study on plutonium aging and is preparing to use the tool for plutonium friction and work function measurements.

X-ray photoelectron spectrometer

Researchers investigate the chemistry of the top few nanometers of a solid sample surface with a Physical Electronics VersaProbe III, which defines the chemistry and reactivity of a given surface.

Time-of-flight secondary ion mass spectrometer

SIMS, or secondary-ion mass spectrometry, is one of the most surface-specific analytical techniques in existence. It provides chemical information from the top few monolayers of a sample surface and is one of the few surface science techniques sensitive to hydrogen. The laboratory's Kore Analytical ToF-SIMS has provided some of the first-ever SIMS spectra from coupon-sized plutonium samples.

Fourier transform infrared and gas chromatography mass spectrometer

These instruments show the coordination of adsorbed molecules on plutonium's surface after controlled exposure to atmospheric gases. With these tools, researchers can simultaneously probe the gas-phase chemistry above a sample surface, providing real-time information on reactions at atmospheric pressures.

Optical surface profilometer

A white light interferometer and a high-precision scanning stage obtain non-contact, 3D optical surface maps that go beyond typical contact-based measurements and can take data on radioactive or air-sensitive samples.

Spectroscopic ellipsometer

This instrument reflects a broad spectrum of polarized light off a sample surface to determine film thickness and optical constants. Materials Science and Technology researchers use the spectroscopic ellipsometer to study plutonium metal surfaces and thin films made of actinides.

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