LAB TOUR QUANTUM OXIDE LAYERS LAB

Opened in the winter of 2025, the Quantum Oxide Layers Lab is where Jennifer Fowlie studies transition metal oxides, advanced materials that show unusual quantum behaviors.

Fowlie, assistant professor of materials science and engineering, and her research team work to create these special materials in precise ways at nanoscale. By combining careful materials design with advanced tools that measure magnetic, electronic, nuclear, and optical properties, they gather insights into how quantum materials behave in electronic applications from touchscreens to quantum information processing platforms.

1. FURNACE

A tube furnace plays a quiet but essential role in shaping transition metal oxides before and after they are grown as thin films. The long, horizontal chamber heats samples to high temperatures under carefully controlled conditions. Whether preparing targets for pulsed laser deposition or refining newly grown films, the furnace ensures the precise crystal structure and chemistry that experiments demand.

What distinguishes this tube furnace is not only its control of atmosphere and temperature, but its ability to measure electrical properties in real time as reactions occur. By flowing oxygen or other gases through the heated chamber, the team fine-tunes oxygen content while tracking changes in conductivity. For transition metal oxides, even small shifts in oxygen stoichiometry can dramatically alter magnetic and electronic behavior, making this in situ measurement critical.

2. PULSED LASER DEPOSITION CHAMBER

The pulsed laser deposition chamber is the starting point for every sample of transition metal oxides. Oxygen-metal compounds with unusual electronic and magnetic behavior, these materials naturally form ceramic crystals—hard, brittle solids with a regular, repeating 3D arrangement of atoms that gives a crystal its structure and properties.

In a highly controlled process, the system grows thin layers of these crystals, one sample at a time, with each run taking a few hours.

A high-powered laser strikes a solid target containing the exact chemical composition. The material vaporizes into a plume and deposits onto a carefully selected crystalline substrate, where it reforms as a precisely structured atomic layer.

The target must match the desired chemical composition precisely, and the substrate determines how the crystal will align as it grows. By changing the target or the substrate, the team can systematically engineer different structures while keeping the rest of the environment constant. That level of control is essential when working with transition metal oxides, the magnetic and electronic properties of which are extremely sensitive to small structural changes.

3. CLEAN ROOM

In the clean room, designed to keep dust and airborne particles away from transition metal oxide samples, the delicate films, which may be only a few nanometers thick, are handled under tightly controlled conditions.

In the lab's workflow, the clean room serves as the bridge between growth and measurement. After being created in the pulsed laser deposition chamber, the films often pass through this controlled environment for final preparation before low temperature studies.

4. CRYOGENIC MEASUREMENT SYSTEM

This is where metal oxides are put to the test. After the samples are fabricated in the pulsed laser deposition chamber, the thin films come to this system where they are cooled to extremely low temperatures and quantum effects become apparent. Many of the exotic properties Fowlie's group studies only emerge in the cold, when thermal noise is reduced and quantum interactions dominate.

The large, vacuum-insulated vessel creates a tightly controlled environment that allows researchers to observe subtle changes in a material's behavior. Inside the system, samples can be subjected to precise temperature control and electrical and magnetic measurement.

5. WIRE BONDER

Here, the team makes first electrical contact with their transition metal oxide devices. Under the microscope, researchers guide hair-thin metal probes onto microscopic contact pads, a delicate process that requires steady hands and careful alignment.

The setup allows the team to test tiny samples without permanently wiring them, ideal for rapid checks of newly prepared films. Before moving on to more specialized low temperature studies, the researchers also measure properties like electrical resistance and current flow to see how a material behaves.

BRIAN SANDALOW

Photos by Jason Brown

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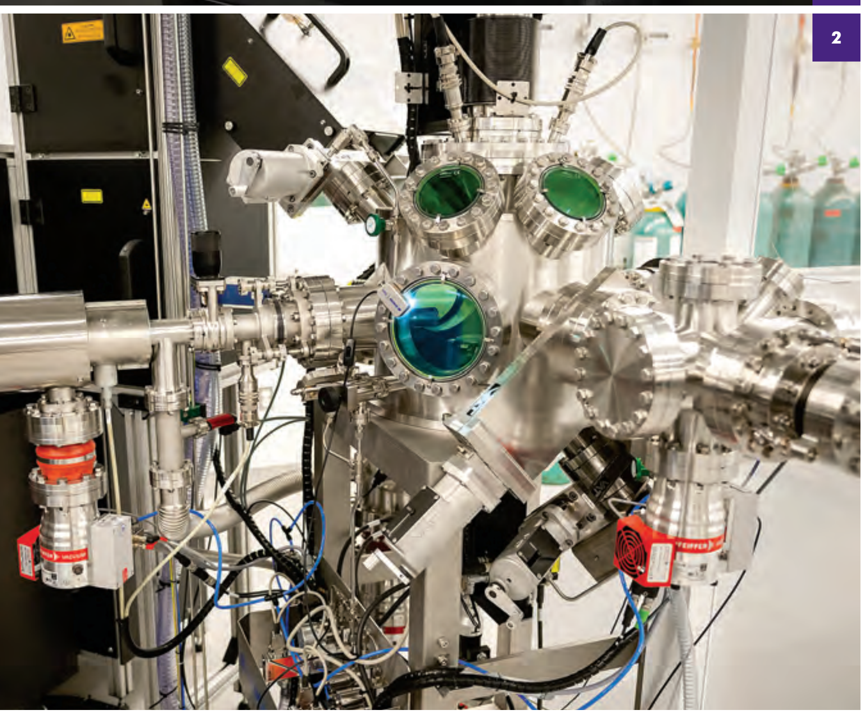
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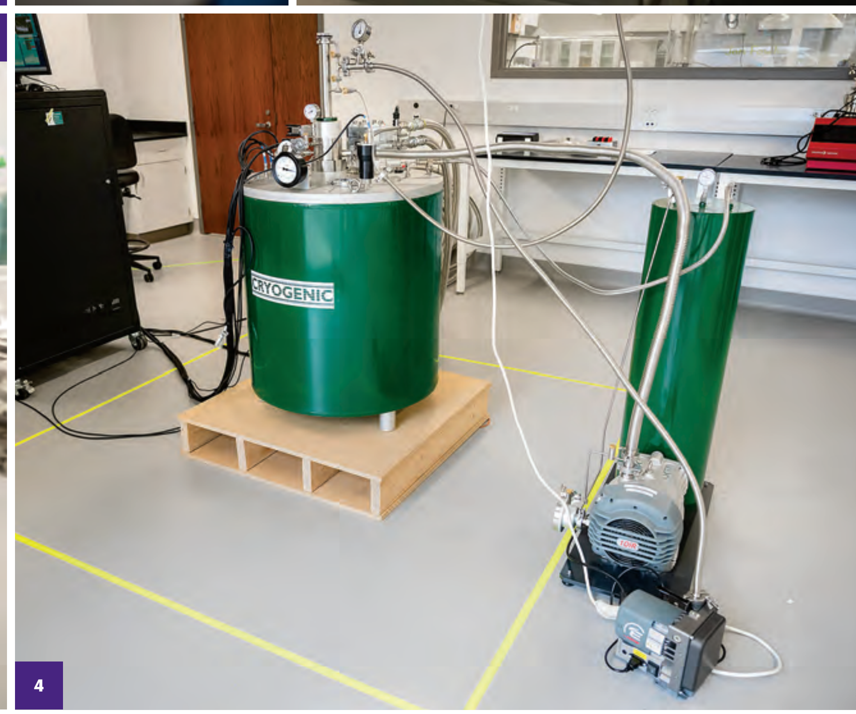

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Jennifer Fowlie
Assistant Professor of Materials Science and Engineering


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Tour the Quantum Oxide Layers Lab
View the lab's devices in action and learn about how these technologies support research.