Oak Ridge National Laboratory’s Materials Plasma Exposure eXperiment (MPEX) is a next-generation linear plasma device that will advance research on the way plasma interacts with materials and components needed for future fusion reactors.

Generating fusion energy requires heating subatomic particles to temperatures hotter than the center of the sun and containing them in magnetic fields hundreds of thousands of times stronger than the Earth’s. When these particles escape the magnetic field and are incident on surrounding materials, the resulting interactions can change their structure entirely.

Currently, only a few linear plasma devices are able to expose neutron-activated materials, while others cannot reach extreme plasma temperatures, nor control electron and ion temperature separately. MPEX will have all of these capabilities, making it integral to efforts to prepare materials for a fusion pilot plant and ultimately fusion power plants.

The project secured US Department of Energy approval in October 2020 for the preparation of the facility and long-lead procurements, and device assembly is projected to begin in 2023.

“MPEX is expected to exceed the conditions of any current device. It can go all the way to fluence levels in DEMO—the machine after ITER—which are relevant for a prototype fusion reactor.”

Phil Ferguson,
MPEX Project Director
A New Breed of Fusion Materials

MPEX will advance the science of plasma–material interactions (PMI), which is essential for a viable path to fusion energy. ORNL brings to this challenge a long history of materials science leadership and the largest US effort in fusion materials.

There are currently no qualified plasma-facing materials and components for fusion reactors. Such materials will need to be strong enough to withstand the harsh radiation and erosion conditions of steady-state fusion reactors running over a long period of time with high-temperature environments and high ion and neutron fluences.

Hot Target

Using MPEX, scientists will strive to advance the science of PMI and the technology of plasma-facing components for fusion reactors. MPEX will also enable researchers to understand how extreme conditions affect the divertor—considered the power and particle “exhaust system” of a fusion reactor—along its length. To achieve these goals, MPEX is being developed in collaboration with ORNL’s capabilities in plasma physics, radio frequency heating, and high heat flux engineering.

Collaboration at Its Finest

ORNL resources and expertise will help MPEX deliver high-impact science. Potential plasma-facing material samples will be exposed in ORNL’s High Flux Isotope Reactor to relevant neutron damage before cooldown and transfer for subsequent plasma exposure in MPEX. By pairing these facilities, ORNL has a unique opportunity to simulate fusion reactor conditions.

The Oak Ridge Leadership Computing Facility’s high-performance computing capabilities will also be of particular importance during this process, as it will be used to model MPEX performance and analyze surfaces of materials exposed to high-fluence MPEX plasmas.

ORNL also will initiate collaborative PMI research with other partners to study the effects of radiation damage and to develop diagnostic capabilities.