UC MULTICAMPUS NATIONAL LAB COLLABORATIVE RESEARCH AND TRAINING AWARDS
2026 Awards

Center for Fusion Energy - Materials and Diagnostics for Extreme Conditions (MDeC)

Lead Principal Investigator: Farhat Beg, Ph.D., UC San Diego
— *Collaborating Sites:* Irvine, Los Angeles, Santa Cruz, Los Alamos, Lawrence Livermore

Project Abstract
The California Center for Fusion Energy – Materials and Diagnostics for Extreme Conditions (MDEC) – is a strategic partnership among four UC campuses (San Diego, Los Angeles, Irvine, and Santa Cruz) and two National Laboratories (LLNL and LANL). This collaboration seeks to transform the scientific, technological, and educational foundations of fusion energy. Recent breakthroughs demonstrating fusion energy gain have fueled growing interest, along with over $10 billion in private investment.
Despite progress, significant engineering and design challenges remain before fusion energy can transition from experiments to commercially viable energy production. A coordinated effort between academia, National Laboratories, and the growing fusion energy private sector is essential. The MDEC Center will adopt a multidisciplinary approach to address grand challenges in the following research areas:
● Materials under extreme conditions: How can we leverage the chemical composition space to develop radiation resistant armor materials? Is there an optimal compromise between fabricability, scaleup and material properties for the materials design loop?
● Diagnostics under extreme radiation: How can we scale critical Inertial Fusion Energy diagnostics to higher repetition rates using numerical tools such as AI? What detection systems can survive reactor level radiation, and what detection paradigms can work across multiple fusion schemes?
● Tritium fuel cycle: How can we improve materials-tritium interactions to limit losses, and how does tritium affect the evolution and aging of materials?
The challenges in fusion energy transcend traditional disciplinary boundaries of physical sciences and engineering, requiring an integrated approach to education and training. The Center will use a multi-front approach offering a comprehensive series of courses on fusion energy, materials, diagnostics, radiation, tritium science and fundamentals of fusion power plants. By providing access to these specialized courses, our goal is to equip the work force of fusion researchers and engineers with the knowledge and skills needed to drive innovation in collaboration with major fusion companies. The Center will have a profound impact on society, expanding technology, education, and enabling new advances in fusion energy.

Predictive Discovery of Radiation-Resistant Alloys for Extreme Fusion Environments

Lead Principal Investigator: Penghui Cao, Ph.D., UC Irvine
— *Collaborating Sites:* Berkeley, Santa Barbara, San Diego, Los Alamos, Lawrence Livermore

Project Abstract
This project will establish a hub for predictive discovery and accelerated demonstration of durable and supply-resilient materials for fusion reactors. We focus on two leading material systems: W-based alloys for plasma-facing components and V-based alloys for structural applications. By combining innovative multi-scale modeling, machine learning/AI, advanced irradiation, and state-of-the-art performance testing, we will uncover the atomic- to microscopic-scale processes that govern defect accumulation and damage evolution under extreme fusion environments. We aim to achieve exceptional radiation tolerance by delocalizing irradiation damage, suppressing defect clustering and helium bubble evolution, and stabilizing microstructures through predictive alloy design and targeted chemical doping. The proposed paradigm for damage-tolerant fusion materials is built on understanding and controlling degradation processes across multiple length and time scales, and by directly probing mechanisms and performance under coupled radiation and thermomechanical extremes. The project brings together a multidisciplinary team spanning materials science, mechanical and nuclear engineering, plasma science, computational modeling, and machine learning across four UC campuses (UC Irvine, UC Santa Barbara, UC San Diego, UC Berkeley) and two national laboratories (LANL, LLNL). The deliverables will be designing materials property maps that identify damage resilience with mechanical performance, providing a platform for selecting, testing, and validating materials at an accelerated rate.