CHESS

CORNELL HIGH ENERGY SYNCHROTRON SOURCE

MATERIALS SOLUTIONS NETWORK

MSN-C

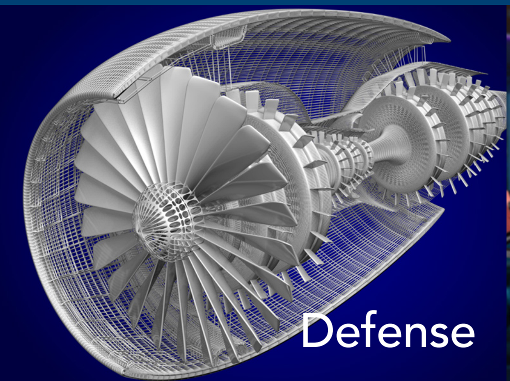
A state-of-the-art X-ray facility providing dedicated access for materials researchers at Air Force, Army, Navy and their collaborators and OEMs

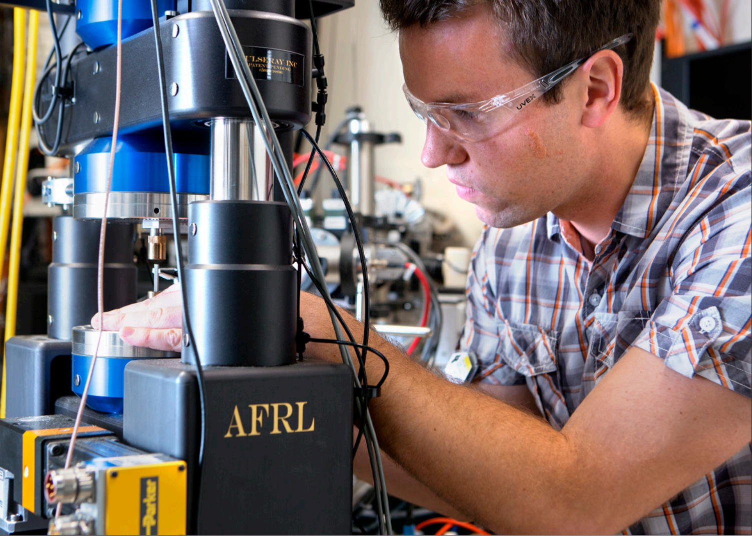
AFRL

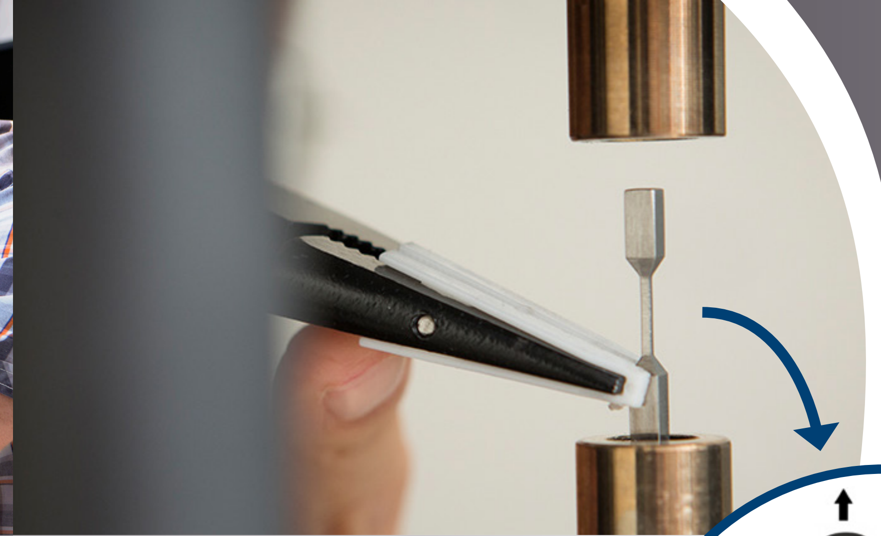
THE AIR FORCE RESEARCH LABORATORY

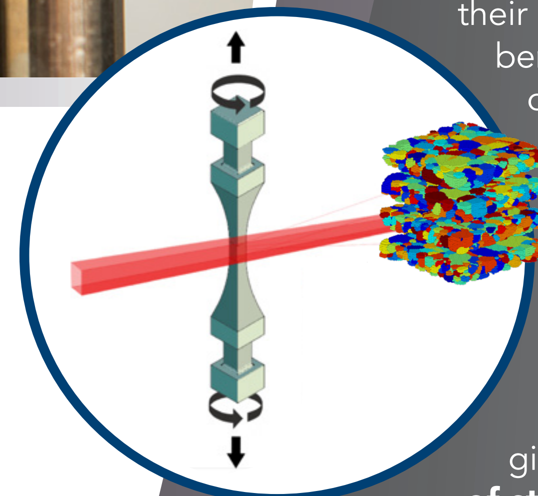
LEAD | DISCOVER | DEVELOP | DELIVER

- Addressing Urgent Manufacturing Challenges
- Atomic-Scale Understanding of Processing & Performance
- Ground Truth for Predictive Modeling
- Export Control / ITAR Compliance









What Makes the Materials Solutions Network Unique?

DEDICATED ACCESS: The dedicated access provided by MSN-C means that projects are **prioritized on the basis of their importance to DOD**, rather than their general scientific interest. Solving modern technological challenges faced by DOD benefits from ever-deeper understanding of age-old design challenges, such as the origin of fatigue failure in engine alloys, as well as new challenges associated with emerging materials processes, such as 3D printing of nanocomposite soft materials and additive manufacturing of metals.

INDUSTRIAL FOCUS: Industrial research projects now have the advantage of dedicated beamtime paired with the expertise at CHESS that is required to perform these studies. The combination of access, training, and experimental standardization of otherwise challenging synchrotron-based techniques gives MSN-C an unparalleled **opportunity to impact the design and manufacture of structural and functional materials**, with implications well-beyond the DOD.

THE UNIQUE POWER OF X-RAYS: High-energy-diffraction microscopy (HEDM), developed by the AFRL and other researchers over the past two decades, allows grain-by-grain level monitoring of metals during processing – such as mechanical loading or heating. Such techniques are now routinely combined with modern computational methods, including machine-learning, to provide new understanding and predictive power of when materials fail. High-energy x-rays can penetrate through thick metallic specimens – as much as an inch of steel, and can be used to characterize quantitatively the structure and mechanical behavior of every crystal within a failing sample in real-time, often with sub-crystal spatial resolution. **Ideally, we are looking everywhere within the sample, all of the time.**

MSN-C provides state-of-the-art x-ray techniques for two classes of investigations: in-*situ*, high-fidelity studies of materials during deformation, heating, or other processes, and detailed interrogation of engineered parts, such as weld assemblies and engine components. Recent work includes probing residual elastic strain maps within 1.25” steel parts. **These methods are particularly attractive to industrial users.**

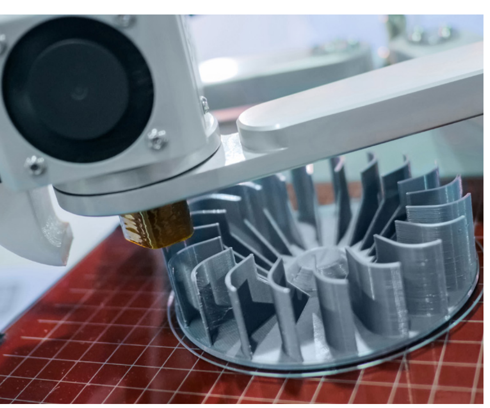
- Predictive modeling of performance in structural metals
- Non-destructive characterization of as-manufactured components
- Performance in additive manufactured components
- Behavior of High Entropy Refractive Alloys
- Predictive modeling of polymer crystallization in structural polymer-matrix composites
- In-*situ* characterization during 3D printing / additive manufacturing
- Machine-learning / AI –based tools to direct synthesis of new materials

ADVANCING THE
FUTURE OF MATERIALS

The Materials Solutions Network at CHESS (MSN-C) consists of two X-ray experimental stations, one optimized for high performance metals and one for polymer-based materials, such as carbon-fiber composites. Together, these facilities provide critical infrastructure in support of two categories of Department of Defense initiatives:

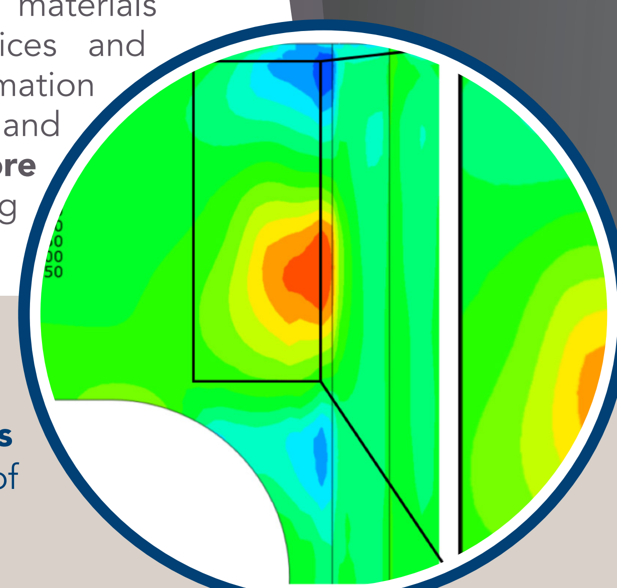
- Materials and Processing **we already use**
- Materials and Processing **we need to design**

High performance alloys of titanium, nickel, aluminum and steel can be found throughout every military aircraft and flight system and have been employed for decades with a long list of industrial OEMs. It is the mission of MSN-C to enhance our understanding of alloy structures and their evolution over a broad range of length scales.

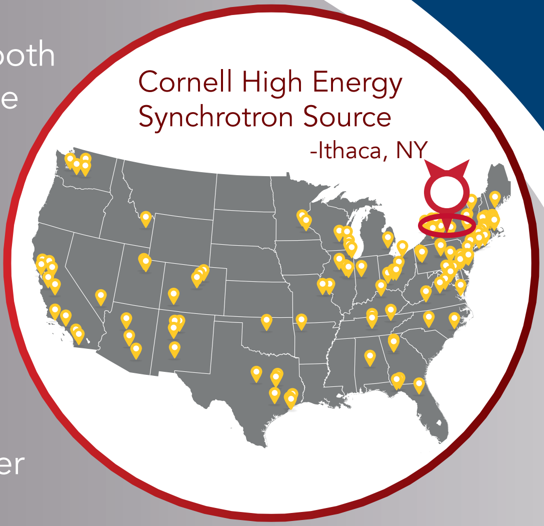


Lightweight, polymer-based materials and composites have emerged in a broad range of Air Force and other DOD applications including new generations of lightweight structural materials and low-cost, flexible, electronic devices and circuits. Better understanding of deformation and damage processes during service and processing conditions will lead to **safer, more efficient materials** and better engineering component designs.

Complementary to in-*situ* experiments, residual stress measurements can be made on deformed samples or engineering components. Using sophisticated positioning equipment, **residual stress measurements** can be made **at depths of 2-3cm in steel**, enabling fast scanning of relatively large regions of an engineering component.



CHESS users come from around the world and represent both academic and corporate communities. The discoveries of these scientists and researchers not only broaden our knowledge of materials but also improve business processes and products.



CHESS is a world-class facility with more than four decades of service to scientists from across the country, and around the world. It is **one of only two sources of high-energy x-rays** in the nation and is a world leader in synchrotron technology development. In 2003, the Nobel Prize in Chemistry was awarded to Dr. Rod McKinnon from Rockefeller University for his work at CHESS.

CHESS is currently undergoing a $15M upgrade that will extend its capabilities for cutting-edge, innovative science and technology. The CHESS-U upgrade will provide the critical leverage to position CHESS as a world leader in synchrotron science. In addition, it will attract the research of more U.S. manufacturers and drive local high-tech businesses.

With the completion of CHESS-U in 2019, CHESS has become the premier synchrotron source in the US for high-energy, high-flux x-ray studies.

Each Year, CHESS has...

~1,200 Users

~30% New users

~350 Graduate Student Users

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