A Vision for the Physical Sciences Directorate at Oak Ridge National Laboratory

J. Charles Barbour

Director, Radiation and Electrical Sciences Center
Sandia National Laboratories
Albuquerque, NM

Executive Champion for Research & Development

Strategic planning & investments ♦ Leadership of interdisciplinary research challenges
Set international agenda for science, technology, and engineering collaborations
Leader in operational excellence and people development

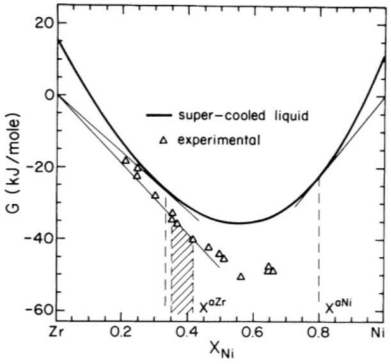
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

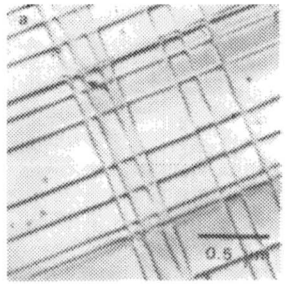
Background

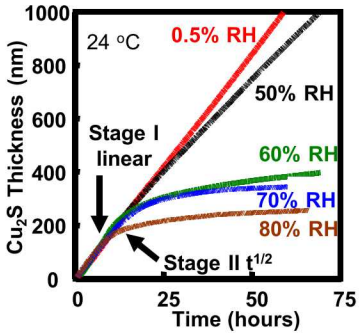
- **1987-present, Sandia National Laboratories, Albuquerque, NM**
  - Director, Radiation and Electrical Sciences Center, 2014 – present
  - Director, Physical, Chemical, and Nano Sciences Center, 2010 – 2014
  - Manager & Senior Manager, 2000-2010
  - Member of Technical Staff, 1987-2000
- **1986, Visiting Scientist - FOM Institute for Atomic and Molecular Physics, Amsterdam; and Philips Research Laboratories, Eindhoven, The Netherlands**
- **1986, Ph.D. Materials Science and Engineering; Cornell University**
  - Thesis: The Diffusion of Nickel in Amorphous Nickel-Zirconium Alloys and the Composition Analysis of Nickel-Silicide Formation in Lateral Diffusion Couples (Advisor: James W. Mayer)
- **1982, M.S. Materials Science and Engineering; Cornell University**
- **1980, B.S. Engineering Physics (Minor: Metallurgy); Colorado School of Mines**

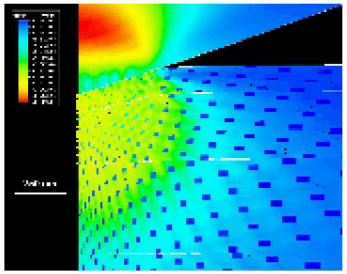
My research

- **Defect physics**
- **Radiation effects**
- **Material performance impacted by radiation and defects**
  - Diffusion and phase transformations in amorphous metals and semiconductors
  - Electrical & optical performance of semiconductor & insulators
  - Impact of defects on corrosion – passivation layers, diffusivity
  - Mechanical performance of nanostructured metals & ceramics









Management Responsibilities

- **Experience leading a science organization with both Office of Science (SC) and applied programs**

- **Dual hat structure at Sandia – programmatic experience with the SC customer base for all Sandia (similarly for NNSA programs)**
  - BES, ASCR, FES, BER, SC-1&2; and ARPA-E $80+M/yr
  - NA-115 (NA-11); and DTRA J9 Nuclear Technologies $120+M/yr

- **Facility responsibilities**
  - Facility hazards from high hazard to light electrical.

BES: Basic Energy Sciences
ASCR: Advanced Scientific Computing Research
FES: Fusion Energy Sciences
BER: Biological and Environmental Research
ARPA-E: Advanced Research Projects Agency – Energy

NA: National Nuclear Security Administration
NA-115: Office of Engineering, Stockpile Assessments, and Responsiveness
DTRA: Defense Threat Reduction Agency

Physical Chemical and Nanoscience Facilities

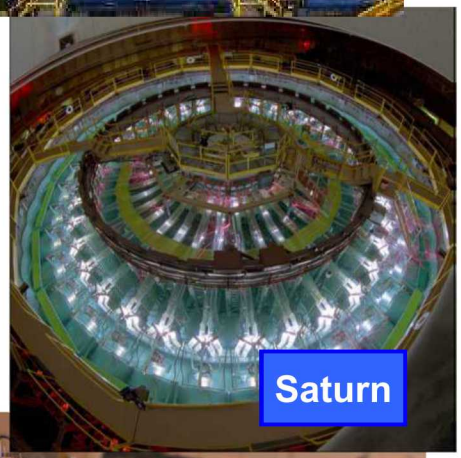
Chemistry & Physics Labs

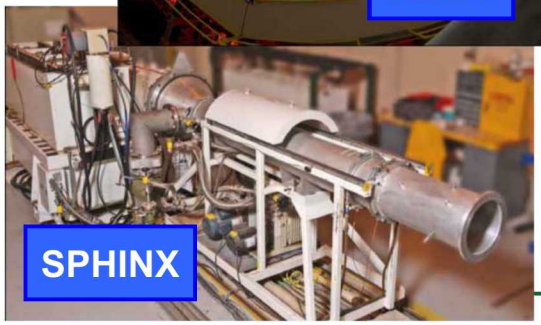
Compound Semiconductor Labs
Microsystems & Engineering Science (MESA)

BES Nanoscale Science Research Centers

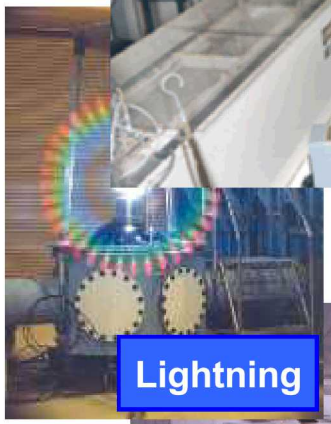
Radiation & Electrical Sciences Facilities

Accelerators

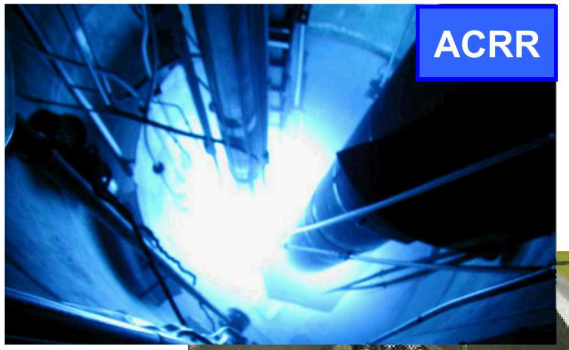


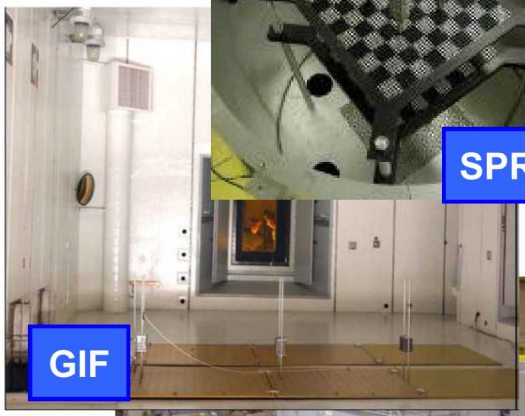


Electromagnetics



Nuclear





Inspire Research Excellence

- Discovery Science – let curiosity flourish
  - Give people the opportunity to take scientific risks
  - Ask good questions and challenge assumptions
  - Understand the potential impact so I can champion the work
- Engage application communities to understand “what keeps them up at night”
  - Pick the problems carefully
  - Know the strengths of my organization
  - Energize an interdisciplinary team (more than my organization)
  - Synthesize possible paths to solutions – I’ve always found a science based solution helps formulate the problem in a new and better way
- Provide a forum for communication and discussion

Vision for Power-on-Demand Research Challenge

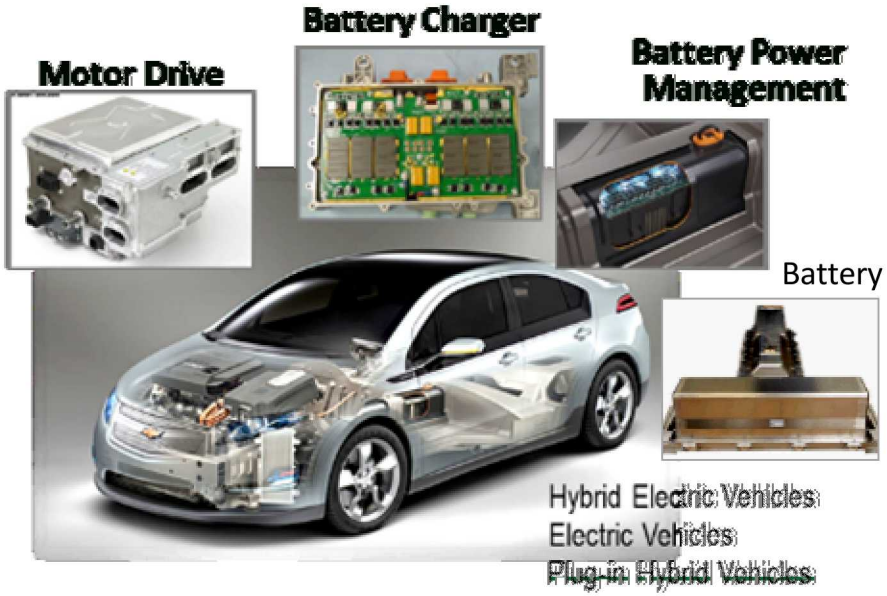
The ubiquitous need for power is accompanied by the need for reduced size and weight, enhanced conformability, and robustness in harsh environments.

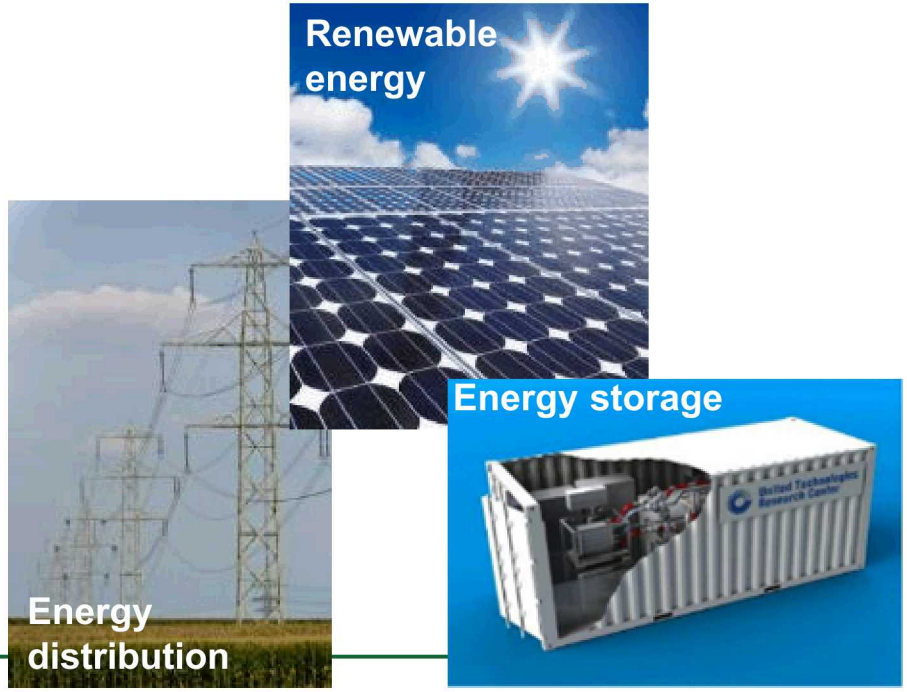
Power on Demand will accelerate revolutionary advances in the key enabling technologies of electrical power systems.

- *By 2025 we will demonstrate a 10X decrease in the size, weight and added power consumption of one or more electrical power systems for both stationary and mobile applications of interest to Sandia's missions.*
- *We will become one of the nation's leading technology innovators in electrical power systems and components.*

Civilian Energy Needs

- Next-generation grid (efficiency & intelligence; long & short term storage)
- Transportation sector (vehicle electrification)
- Solar PV, PV Inverters and Wind Inverters (clean electricity; key enabling technology for increasing grid renewable generation)
- Building and Industrial efficiency (variable speed electrical motors for HVAC, elevators, industry)
- Small power supplies and appliances – computers, solid-state lighting power drivers, appliances
- Electric rail, aeronautical



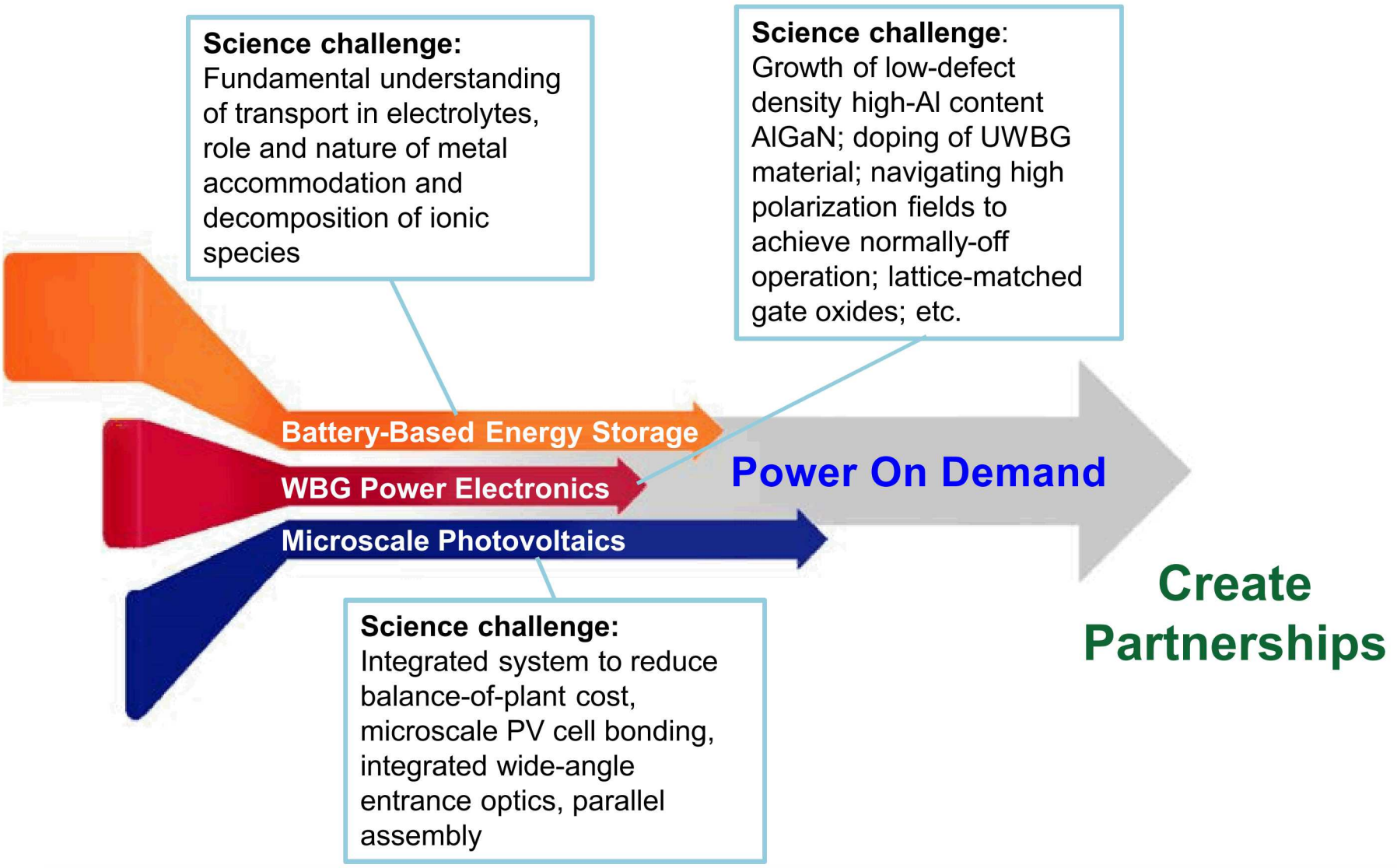


National Security Mission Needs

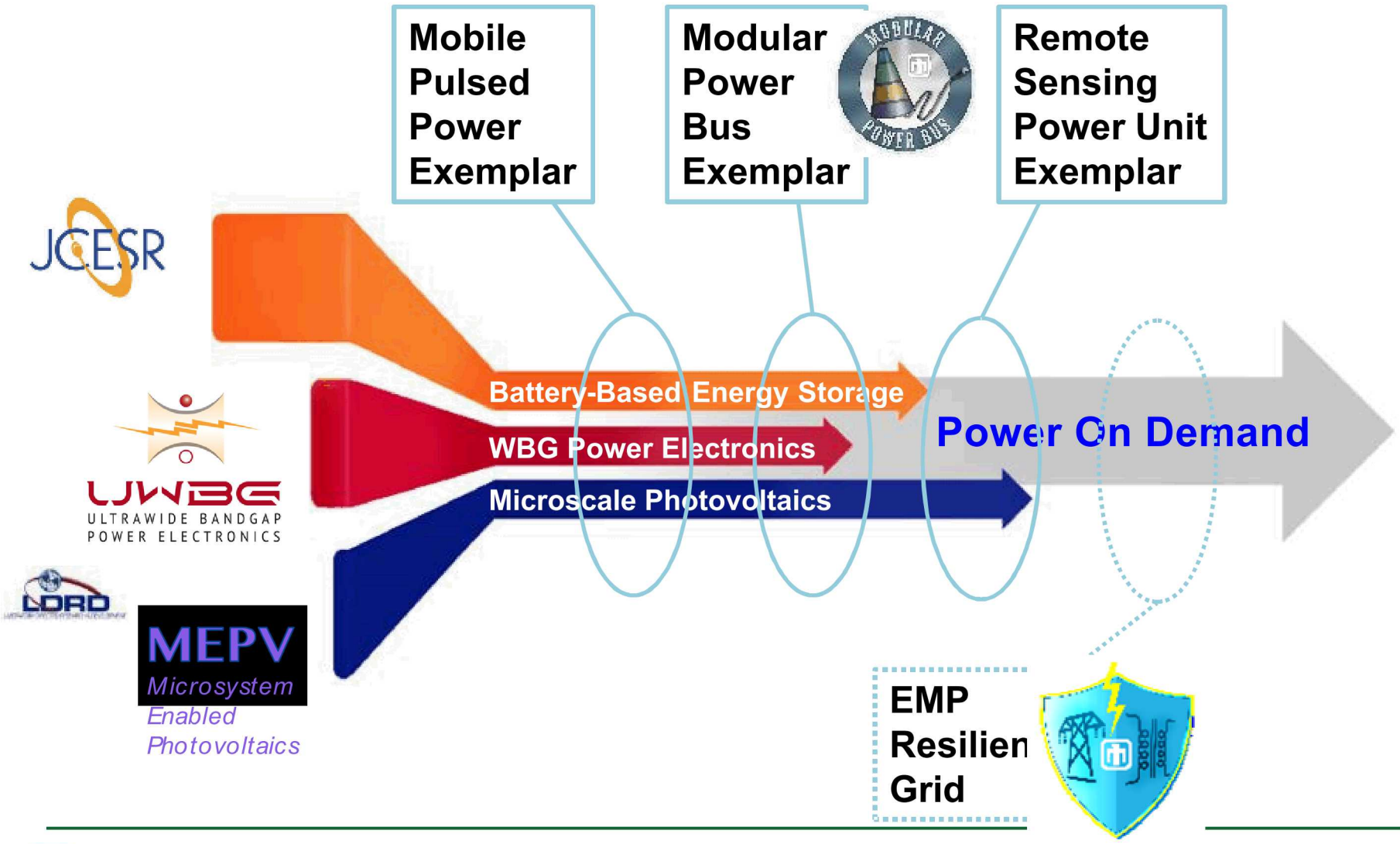
- Aeronautical applications (SWaP requirements)
- Electromagnetic aircraft catapults for navy carriers
- Extended operation of UAVs and robotics
- Operational lifetime of remote sensors
- Recharging and rejuvenation of satellites
- Portable power for the warfighter & first responders
- Electrical power for FOBs
- Replacements for high-voltage standoff components
- Components enabling more efficient radiation-hardened systems
- Compact, reliable, radiation-hard power conversion for satellite systems

Size, Weight, and Power (SWaP) issues are paramount for all of these applications

Three Research Themes: Identify Science Challenges



Integration Exemplars Tie Thrusts Together



The role of an Associate Lab Director

- Associate Laboratory Director role
  - Assure the Physical Science Directorate (PSD) is meeting the Science Mission for the Office of Science
  - Recognize challenges that may be coming and formulate a strategy to deal with them
  - Lead PSD & ORNL in developing new capabilities and opportunities for the country
  - Be a champion for PSD & ORNL outside the Lab to build/maintain partnerships with universities, other Labs, and industry.
  - Influence the national science agenda for tackling the most important science questions
  - Be a team player and resource on the Executive Leadership Team – partner with the other ALDs to make ORNL strong through collaborative integration across the Lab
    - My breadth of experience will add to and complement the team

Vision – Physical Science Directorate

- Physical Sciences Directorate

  Be recognized as the nation's leader in Energy Sciences and Nuclear Physics

- Mission – be science leaders while being good collaborators
  - Stellar record of publications, presentations, and awards
  - Creating new capabilities that will attract new users / collaborators
  - Active engagement in scientific societies – organizing meetings and committees
  - Lead BES workshops and reviews (BESAC)
    - Opportunities – Basic Research Needs (BRN) for Future Nuclear Energy, Energy Storage, Novel Experimental Tools
  - Take a systems look to see how the science can impact application sooner

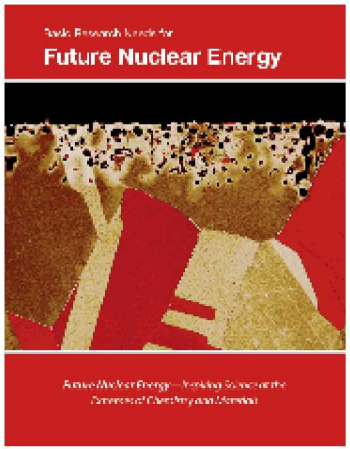
    (I can bring some of my strengths to bear here)

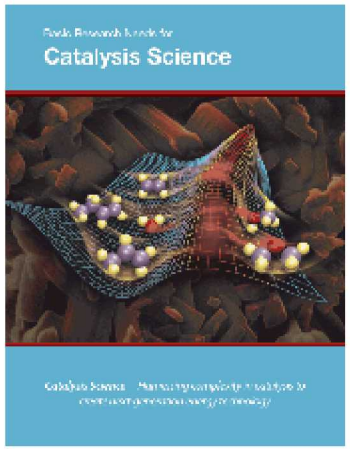
Mission Assurance and Programmatic Success

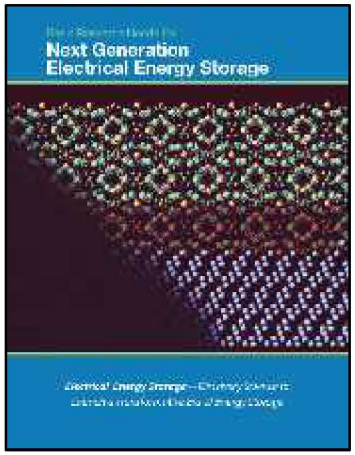
- Engage the sponsor - transparency
- Scientific/Technical Assurance
  - Quality of staff – who we attract and retain (Fellows, Awards, Scientific Society Leadership, commitment to diversity and inclusion)
  - Publications
  - New initiatives (EFRC competition, …)
  - Leading and participating in science strategy workshops
  - Peer review before the sponsor peer review
  - Commitment to ORNL Research Code of Conduct
- Operational Excellence
  - Utilize independent reviews
  - Safety – safe by design intent
  - Security – no single point failures
  - Environment – system perspective

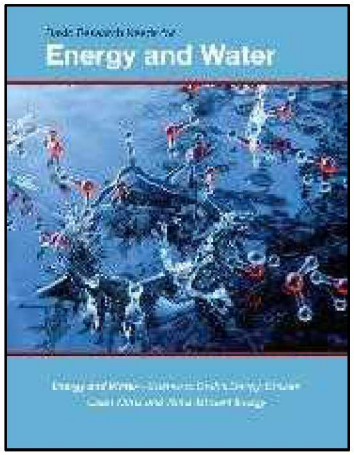
BES Communications

- BRN Workshop Report / Brochures

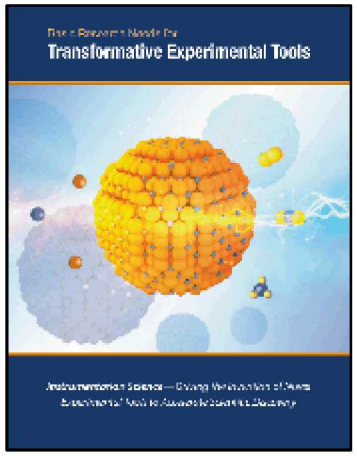


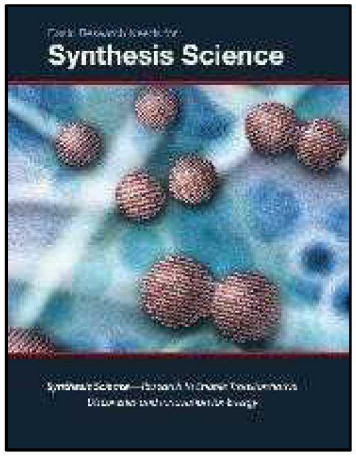


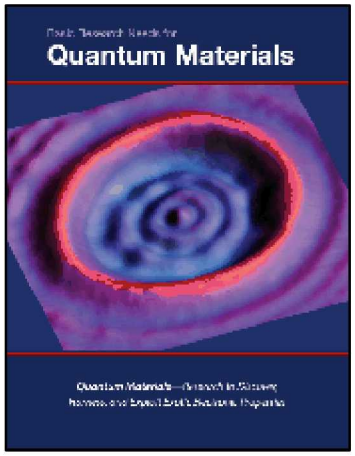


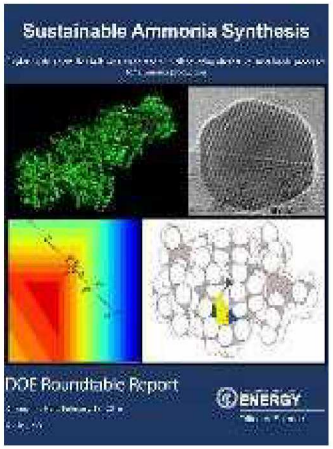


2017









2016

https://science.energy.gov/bes/community-resources/overview-brochures/

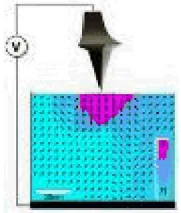
Center for Nanophase Materials Sciences

In-house research themes

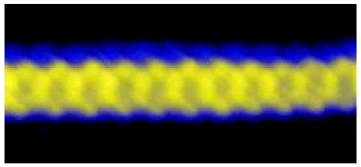
- Electronic and Ionic Functionality on the Nanoscale
- Functional Polymer and Hybrid Architectures
- Collective Phenomena in Nanophases

Research Areas

- Interface Directed Assembly
- Directed Nanoscale Transformations of Materials
- Electromechanical Phenomena
- Heterogeneities in Low-Dimensional Materials



See Li et al., *Nature Communications* 6.8985 (2016)



See Ma et al., *Nature Communications* (13 March 2017)

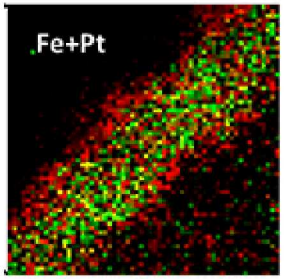
See Nicholl et al., *PRL* 118.266101 (2017)

Chemical Sciences Division

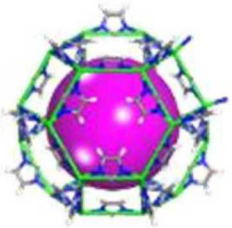
- Interfacial science
- Catalysis
- Geosciences
- Separations
- Chemical imaging
- Polymer science

- Expertise in the fluid-solid interface (EFRC)

See Kolesnikov et al., *PRL* 116.167802 (2016)



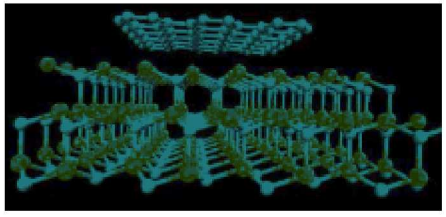
See Zhu et al., *JACS* 137.10156 (2015)

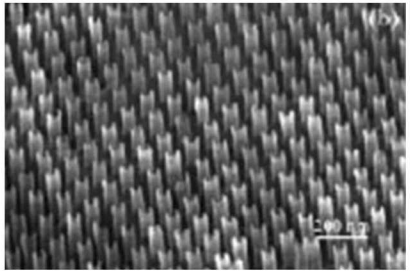


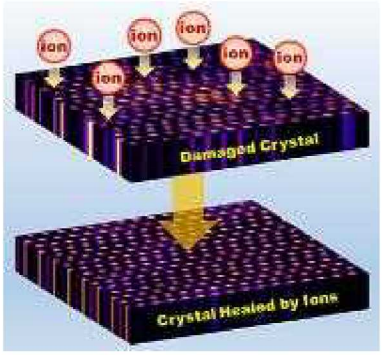
See Zhang et al., *Nano Lett.* 15.3398 (2015)

Materials Science & Technology Division

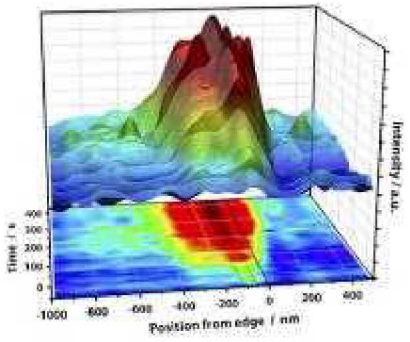
- Theory and modeling
- Synthesis of condensed matter systems
- Materials characterization
- Mechanical properties
- Properties in extreme environments (EFRC)
- Applied materials physics







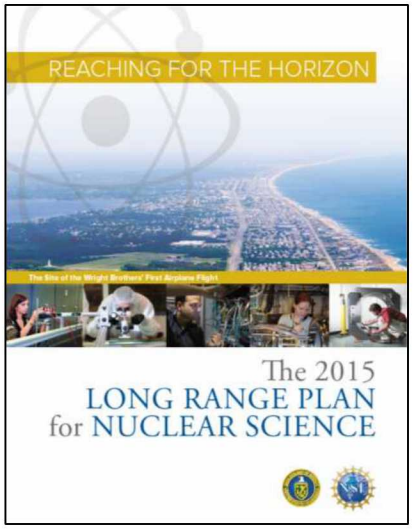
See Zhang et al., *Nature Communications* 6.8049 (2015)

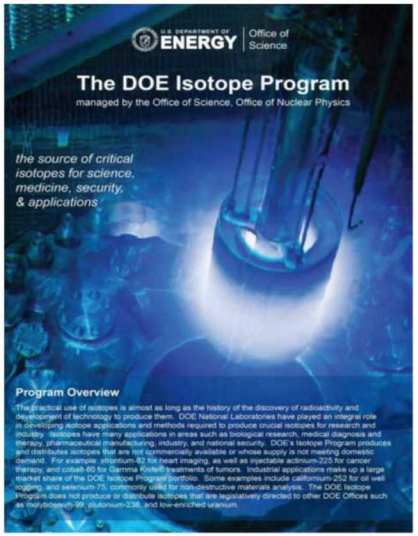


See Sacci et al., *Nano Lett.* 15.2011 (2015)

Physics Division

- Neutron physics
- Detectors
- Theoretical physics
- Accelerators and sources
- Low energy nuclear physics
- Experimental astrophysics
- Heavy ion reactions
- Isotopes





ORNL well represented in planning and results.

More to learn here for me – strong partnership

Final Thoughts

The Physical Sciences Directorate has world-class researchers and facilities that lead the nation in discovery science and applications

My goal is to partner with the directorate management team to maintain a vibrant research environment and develop new opportunities

- Foster collaborations within the directorate
  - Across the Lab
  - With universities, other national labs, and industry

- Opportunities within SC and applied programs for energy impact
- Opportunities for national security impact