Sandia National Laboratories

Exceptional service in the national interest

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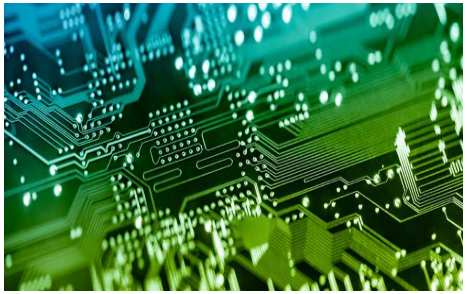
Licensing & Partnerships Opportunities
Sandia National Laboratories

Debi Hudgens, PhD, MBA
Business Development & Licensing
February 2018



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Sandia National Laboratories

Overview

- Established 1949; Manhattan Project
- Federal Lab funded by DOE, DOD, DOHS

  Total Funding: FY2016 - $3.1B

- Labs span diverse range technology areas

  Bioscience
  Computing & Info Sys.
  Electromagnetics
  Engineering Science
  Geoscience
  Material Science
  Nanodevice & Microsystems
  Radiation Effects & High Energy Density Science
  Robotics

- Primary R&D Facilities:

  Albuquerque, NM (~9,700)
  Livermore, CA (~1,300)

Additional facilities - Tonopah Test Range (NV), Kauai Test Facility (HI), Carlsbad (NM)

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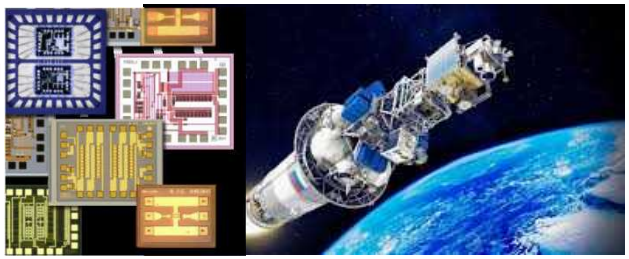
History of Innovation

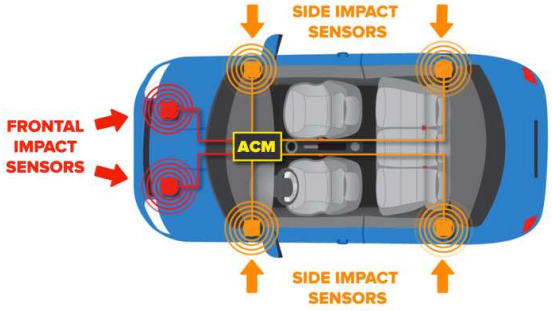
Cleanroom

Radiation Hardened Microelectronics (Space Exploration)

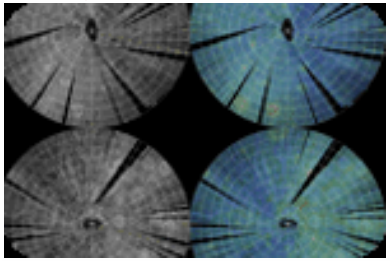


Lead-free Solder

Airbag Sensors



Synthetic Aperture Radar



Decontamination Foam

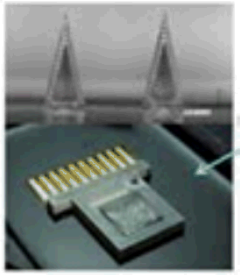
3D Printing

Oil & Gas Enabling Tech

PDC Drill Bit

Implantable Insulin Pump

Microneedle Sensors



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Partnering

Licensing

- Test & Evaluation for short-term evaluation or non-commercial research
- License Option Agreement gives limited term right to obtain license
- Commercial License to patents, copyrights, trademarks
- Bailment provides loan of tangible property incorporating SNL IP

Strategic Partnership Program (SPP)

- Industry, non-profits, other non-federal entities (NFE)
- Define SOW that uses SNL's *unique* facilities, equipment, personnel
- Subject Inventions-US entity/private funds ownership
- Requires either advanced payment/payment plan with 60 day reserve

Collaborative Research and Development Agreement (CRADA)

- Collaborative work between federal lab(s) and non-federal entity
- Longer-term relationships last several years
- Subject inventions - option to license
- Requires either advanced payment/payment with 60 day reserve

$988M
FY 2016

User Facilities

- State-of-the-art facilities open to industrial and academic users
- Proprietary (full cost recovery) vs non-proprietary (typically publication)

IP

Sandia National Laboratories

Successes

BASF We create chemistry

3M

intel

Abbott

GM

CELEBRATION 25th ANNIVERSARY

BOEING

CORNING

MONSANTO

GE Global Research

CAT

P&G

Sandia National Laboratories

Core Competencies

3D Printing

Batteries

Clean Water

Pulp & Paper

Catalysts

Metamaterials

Coatings

Sandia National Laboratories

3D Printing

Advanced Materials-Metals (plastics, ceramics)

Design-Analysis-driven software, PLATO

Reliability Testing-HTS “Al Instante” w/ multiple probe (size-dependent property distributions, fracture toughness/fatigue resistance, microstructural heterogeneities)

Multi-Material Printing

Additive Manufacturing

SD#14202-Low Temperature Copper NP

SD#13734-Nickel Metal Nanoparticles

SD#13868-Metallization of 3D-Printed Plastics by Polyamine Functionalization

SD#13887-AM of Crystalline Semiconductor Material

SD#13428-Novel Powder Delivery Nozzles for LENS Deposition

IP

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Battery Technology

Lithium-Ion

- SD#11322-Solid State Lithium Battery
- SD#14200-Increase Capacity Lithium Thionyl Chloride Electrochemical Cells
- SD#12015-Lithium Battery Cathode
- SD#12924-Organosilicon Based Electrolytes for Long-Life Lithium Batteries
- SD#14582- Nanoporous Carbon as an Anode for Electrochemical Energy Storage

Li^+

Sodium-Ion

Na^+

- SD#13942-MOF Electrodes for Sodium Ion Batteries

Magnesium-Ion

Mg^{2+}

- SD#13772-Rechargeable Magnesium Ion Battery w/Nanoporus Host electrode for Reversible Magnesium Ion

Flow Batteries

- SD#12419-Polyoxometalate Flow Battery
- SD#13042-Polyarene Mediators for Mediate Redox Flow Battery
- SD#14221-Method for Maximizing Energy Density in Redox Flow Battery Electrolytes
- SD#11523-Synthesis of Electroactive Ionic Liquid for Flow Battery Applications

BATLab-Battery Abuse Testing Lab (safety, reliability, failure analysis)

IP

Water/Pulp & Paper/Catalysts

Clean Water

Desalination

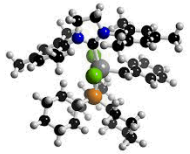
- SD#11775-Biomimetic Membranes for Water Desalination
- SD#8608-Use of Novel Clathrate Hydrates for Desalination

- Arsenic Removal
  - SD#7162-Zirconium-Modified Materials for Selective Adsorption and Removal Aq. As SD#7871-MgO Doped with a Divalent or Trivalent Metal Cation for Removing Arsenic
- Water Treatment
  - SD#22604-On-site recycling of drilling water using graphene-based membranes
  - SD#11164 - Optimized Alumina Coagulation for Water Purification

Pulp & Paper

- SD#13241-Metal Organic Frameworks Cleavage Aryl-Ether Bonds in Lignin
- SD#14022-Synthesis & Characterization of New Catalysts for Oxidative Degradation of Lignin

Catalysts



- SD#13744-Manganese Oxide/PEDOT Composite Electrocatalysts
- SD#7217-Maximal Dispersion in Metal Catalysis
- SD#13867-NCCP Electrocatalyst for Water Splitting

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stryker

Core Competencies

Optics/Imaging Software

3D Printing - Metals

Metamaterials

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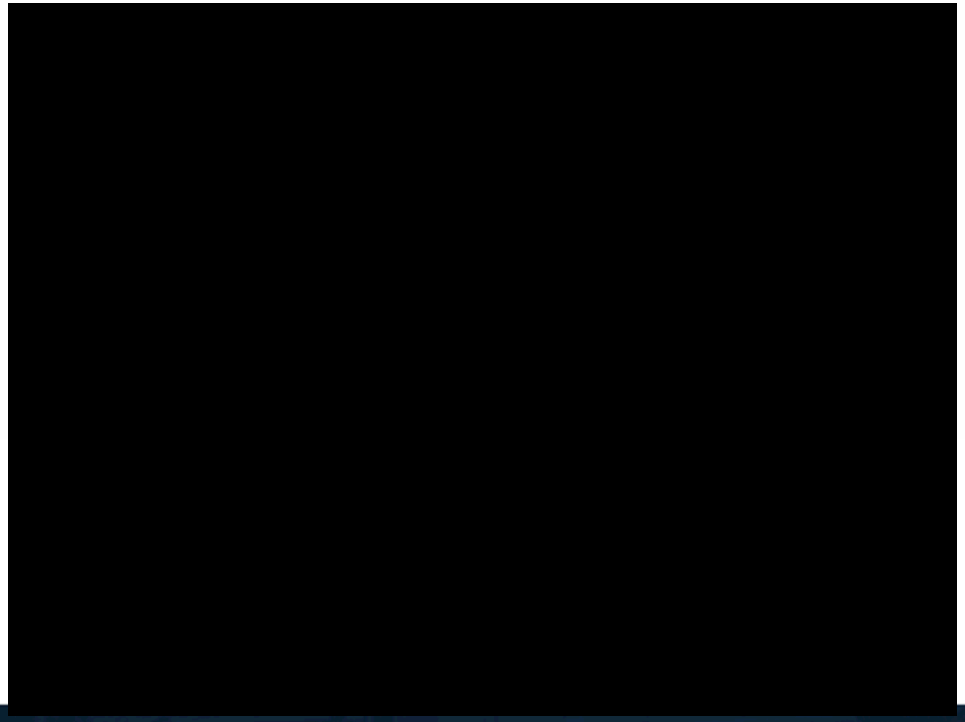
Optics/Imaging

- Optical Sciences Group
  - Laser Source Development, Non-linear Optics, Optical Materials
- Fast Zoom Scope (SWiCK Zoom)
  - **Wi**de-angle qui**CK** zoom - novel method to provide true optical zoom
  - Cooperatively vary the focal length of multiple active elements
  - Extremely fast, variable magnification; size/weight/power/reliability



Issued Patents

SD#10850-Direct View Zoom Scope with Single Focal Plane and Adaptable Reticle (US 9,494,787, Issued 15-Nov-16)

SD#7852-Active Optical Zoom System(US 6,977,777, Issued 20-Dec-05)

3D Printing

Advanced Materials-Metals (plastics, ceramics)

Design-Analysis-driven software, PLATO

Reliability Testing-HTS “Al Instante” w/ multiple probe (size-dependent property distributions, fracture toughness/fatigue resistance, microstructural heterogeneities)

Multi-Material Printing

Additive Manufacturing

SD#14202-Low Temperature Copper NP

SD# 13734-Nickel Metal Nanoparticles

SD#13868-Metallization of 3D-Printed Plastics by Polyamine Functionalization

SD#13887-AM of Crystalline Semiconductor Material

SD#13428-Novel Powder Delivery Nozzles for LENS Deposition

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Core Competencies

Wireless Communication

System Hardware

Software

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Zero Power Radio Receiver

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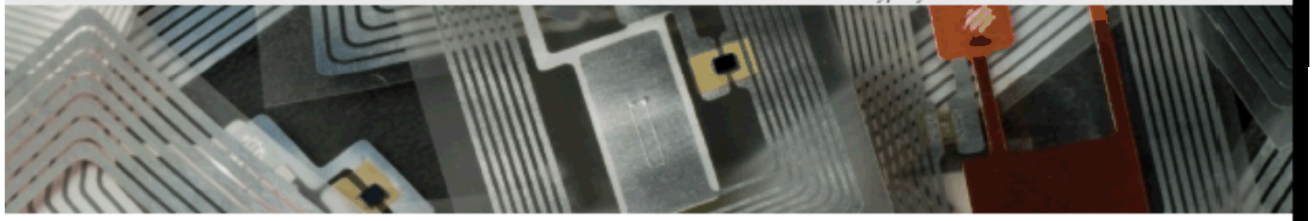
ZERO-POWER RADIO RECEIVER

U.S. Patent No. U.S. 7,397,301; 8,687,674; 9,460,321
Technology Readiness Level: 6

Prototype system is tested in a relevant environment



Sandia has developed a miniature, zero-power radio receiver that can be easily integrated in a wide range of devices to provide continuous wireless connectivity. The underlying principle behind the Zero-Power Receiver is that the powered radio frequency electronics that are used in most wireless receivers can be replaced with electronics that require no power supply or battery. Using this technology, a short range radio receiver (< 100m) can be built that uses no power other than the received RF signal. A longer range radio receiver can also be built that uses only DC amplification, for a total power consumption that is about 10,000x lower than a conventional radio receiver operating at a comparable range.

The Zero-Power Receiver directly demodulates an amplitude modulated wake-up signal sent from a transmitter. The amplitude modulation can be sent using pulse coding to provide a unique device selective turn-on signal to the Zero-Power Receiver. It uses Sandia's patented pyroelectric demodulator to provide direct RF-to-baseband conversion over a wide RF input frequency range and modulation bandwidths. The input impedance of the pyroelectric demodulator provides a match to 50 Ohm circuitry over a very wide bandwidth, ultimately only limited by the electronics packaging that contains the device.

This technology solves multiple communication issues. When incorporated into a cellular phone or GPS, it eliminates the need for the device to constantly power on and off waiting for contact—greatly extending battery life. It can also greatly increase range and decrease size of currently available RFIDs.

TECHNOLOGICAL BENEFITS

- Completely unpowered operation for short range receivers
- Ultra-low power for long range receivers
- Extremely wide input bandwidth

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Digital Communication

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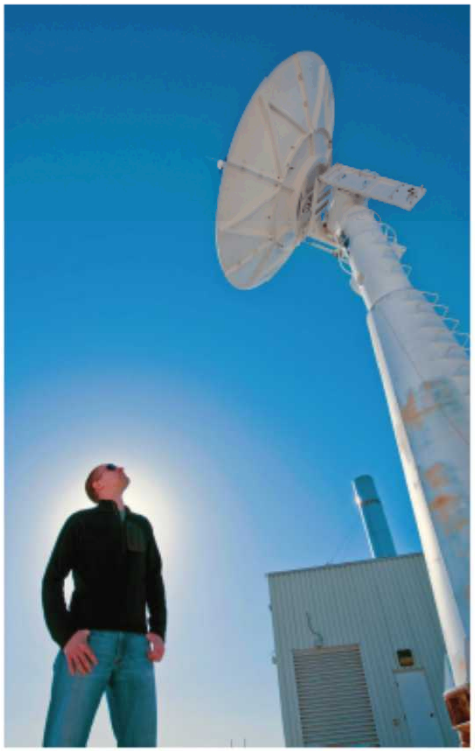
DIGITAL COMMUNICATION: SIGNAL COMBINING & CHANNEL ESTIMATION

US Pat. Nos. 7,653,155 & 8,009,772
Technology Readiness Level: 5
Key components have been demonstrated in a relevant environment

Technology Description

Many communication systems employ multi-channels that transmit and receive a common signal. In these systems, the common signal is combined at the receiver to achieve maximum channel capacity. During the combining of such signals the delay and phase parameters are estimated based on a convolution decoding operation and are removed from the signal. At low signal to noise ratios these parameters become difficult to estimate and impractical to implement.

The combination of these two Sandia technological advances introduce a new method whereby the channel parameters are estimated and removed simultaneously using a convolutional decoding operation, while being combined by the receiver. This new method allows for the signal combing to occur at low signal to noise ratios which improves the over all channel capacity without losing functionality.



Technological Benefits

- Improvement of overall channel capacity
- Improved signal to noise ratio
- Simplification of signal receiving method

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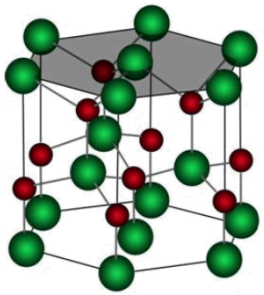
Core Competencies

Semiconductors

Displays

Sandia National Laboratories

LED – Optical Materials



Growth of high-quality optical semiconductor materials, in bulk or nanostructure form

III-N Growth, High Quality

US7915626 Aluminum Nitride Transitional Layer for Reducing Dislocation Density

US8349633 Aluminum Nitride Transitional Layer for Reducing Dislocation Density

US8741748 Method to Grow Group III-Nitrides on Copper using Passivation Layers

US6599362 Substrate Texturing for Cantilever Epitaxy of III-N and Other Materials

US7435297 Molten-Salt-Based Growth of Group III Nitrides

US8425681 Low-Dislocation-Density Epitatial Layers Grown by Defect Filtering by

III-N Growth, Doping

US7449404 Method for Improving Mg Doping during Group-III Nitrides MOCVD

III-N Nanowires

US7745315 Highly Aligned Vertical GaN Nanowires Using Submonolayer Metal Catalysts

US7670933 Nanowire-Templated Lateral Epitaxial Growth of Non-polar Group III Nitride

Other Materials

US6071109 Method of Making AlInSb by Metal-Organic Vapor Deposition

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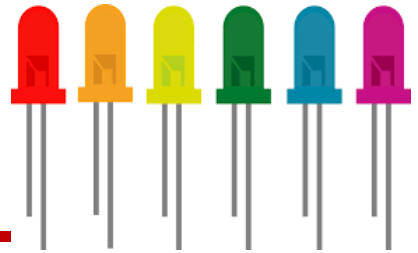
LED – Structure & Design



Efficiency of LED devices, scalability. Nanostructured LED elements for efficiency, wavelength tuning, and white-balance.

General- All Wavelengths

US5493577 Efficient Semiconductor Light-Emitting Device and Method

US6768256 Photonic Crystal Light Source

Visible

US8451877 High Efficiency III-Nitride Light-Emitting Diodes

US8653500 Volume-scalable high-brightness three-dimensional visible light source

US8785905 Amber Light-Emitting Diode Comprising a Group III-Nitride Nanowire

Broadband/white

US6665329 Broadband Visible Light Source Based on AlInGaN Light Emitting Diodes

US7235190 Nanocluster-Based White-Light-Emitting Material Employing Surface Tuning

Infrared

US5995529 Infrared Light Sources with Semimetal Electron Injection

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