Solid-State Lighting Science

Energy Frontier Research Center

Science for our Nation's Energy Future

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Director
Jerry A. Simmons

Co-Director
Michael E. Coltrin

Lead Institution
Sandia National Laboratories

Partner Institutions
Rensselaer Polytechnic University
The University of New Mexico
Northwestern University
University of Massachusetts Lowell
Los Alamos National Laboratory
Philips Lumileds
California Institute of Technology

Research Topics

- Point Defects in InGaN: Microscopic Origin and Influence on Macroscopic Luminescence
- Competing Energy Conversion Routes in Light-Emitting InGaN
- Lasers for Solid-State Lighting
- Strongly Coupled Exciton-Photon Systems
- Dipole-dipole Energy Transfer between Nanostructures
- Surface Plasmonic Intermediaries to Exciton-Photon Interactions
- Nanowires: Synthesis and Properties of Radial Heterostructures
- Crystal Morphology Evolution during Patterned Growth and Coalscence
- Nanodots: Nonlinear Luminescence Dynamics
- Novel Eu+++ Materials for Wavelength Downconversion

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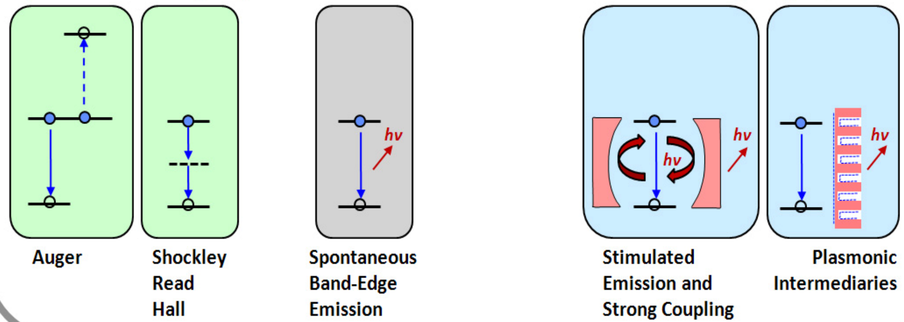
1 Competing Radiative and Non-Radiative Processes

Develop a microscopic understanding of the competition between radiative and non-radiative e-h recombination: spontaneous emission from planar structures.

2 Beyond Free-Space Spontaneous Emission

Explore energy conversion routes that short-circuit conventional spontaneous emission but end in free-space photons.



3 Beyond-2D

Explore the use of non-planar nanoscale structures to modify energy conversion routes so that they may be (a) isolated and better understood, and (b) engineered and optimized.

Mission

We seek to improve the energy-efficiency of the way we light our homes and offices, which currently accounts for 20% of the nation's electrical energy use. Solid-State Lighting (SSL) has the potential to cut that energy consumption in half – or even more.

The SSLS EFRC seeks to:

1) Deepen the foundational science underlying SSL technology while informing and being informed by SSL technology

2) Create an environment that brings together a critical mass of world-class scientists & resources to enable synergistic collaboration that is more than the sum of its parts.

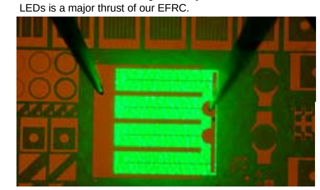
3) Share knowledge actively with specialists (scientists, technologists) and non-specialists (students, public, and government).

Why is SSL Important?

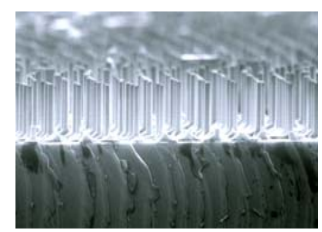
Lighting uses ~20% of U.S. electricity, ~$50B/year. Solid-state lighting (SSL) could reduce that energy use by 3–6 times. SSL devices use semiconductors (crystalline, organic, or polymer light-emitting diodes) to produce light rather than filaments / plasma / gas. Compared to incandescent lights, SSL creates visible light with greatly reduced heat generation / parasitic energy loss, much greater shock / vibration resistance, with lifetimes of 15 years or more. SSL is replacing incandescents in many applications requiring durability, compactness, cool operation and/or directionality. However, currently SSL is still ~4-6 times away from achieving its full potential.

InGaN-based growth: Metalorganic chemical vapor deposition (MOCVD) is used for the growth of the custom InGaN-based multiple quantum well and LED structures studied in the Solid-State Lighting Science EFRC.

Evaluating Efficiency: Emission from a green light-emitting diode (LED) test structure fabricated at Sandia National Laboratories. Understanding efficiency limitations of InGaN LEDs is a major thrust of our EFRC.



Photoluminescence (PL) lifetime measurement: Researchers measure the PL lifetime of a quantum dot solution. We are developing these materials as red-emitters for SSL, in an effort to produce highly efficient light sources with good color rendering.



Nanowire-based LEDs: SEM of an ordered gallium nitride (GaN) nanowire array fabricated on sapphire wafers by a two-step etching process. GaN-based nanowires may be used to create higher performance LEDs in the future due to their unique properties.

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