Energy Frontier Research Center for Solid-State Lighting Science

by J. A. Simmons, M. E. Coltrin, and J. Y. Tsao

Motivation—Sandia National Laboratories will be home to one of 46 multi-million-dollar Energy Frontier Research Centers (EFRCs). The EFRCs, which will pursue advanced research on energy topics, are funded by the U.S. Department of Energy Office of Science. Our Solid-State Lighting (SSL) Science EFRC will receive $18 million in funding over the course of five years under this award.

Accomplishment—The overarching theme of our EFRC is the exploration of energy conversion in tailored photonic structures, a theme that is at the heart of SSL and other energy technologies and a theme of major scientific interest as discovery-class research. The EFRC will have three scientific Thrusts.

The first scientific Thrust is “Beyond 2D: Luminescent Nanowires, Nanodots and Hybrid Structures.” In this Thrust, we are studying energy conversion routes in 1D and 0D nanostructures that go beyond the conventional 2D planar heterostructures typical of SSL technology. These nanostructures are scientifically interesting as vehicles for the science of the very small and for studying how energy quantization and conversion are influenced by dimensionality and proximity to surfaces and interfaces. Also, because of fundamental differences in how lower dimensional structures are synthesized and how they accommodate lattice mismatch and strain, these structures will allow study of defect-mediated energy conversion routes different from those occurring in traditional 2D heterostructures.

The second Thrust is “Beyond Perturbations: Light and Matter in Subwavelength Photonic Structures.” We are investigating energy conversion routes in subwavelength photonic structures in which electromagnetic fields are stronger or more localized, and photonic densities of states more exquisitely controlled, than in structures typical of current SSL. Such extreme conditions are scientifically interesting as vehicles for the science of coherent, many-body phenomena. As new energy conversion routes are explored, entirely new SSL materials structures may arise from their understanding.

The third Thrust is “Wide-Bandgap Materials and Properties: Foundational Understanding and Beyond.” We seek to understand radiative efficiency, which is due to the competition between radiative pathways and undesirable non-radiative pathways that produce heat instead of light. We will develop deeper insights into the synthesis of wide-bandgap materials, and the interplay between their defect and luminescent properties – both as applied to current SSL as well as to the first two Thrusts.

This EFRC includes collaborations with scientists at Rensselaer Polytechnic Institute, the Univ. of New Mexico, Caltech, LANL, Yale, Northwestern Univ., the Univ. of Massachusetts-Lowell, and Philips Lumileds Lighting.

Significance—Our fundamental scientific research has the goal of improving the energy-efficiency in the way we light our homes and offices. Currently, over 20% of the country’s electrical energy is consumed by lighting. Solid-state lighting has the potential to cut that energy consumption in half or even more. Our science breakthroughs in photonic energy conversion may also impact solar photovoltaic technologies.

Sponsor for various phases of this work include: DOE Office of Basic Energy Sciences

Contact: Jerry A. Simmons, Semiconductor and Optical Sciences
Phone: (505) 844-8402, Fax: (505) 844-4045, E-mail: jsimmon@sandia.gov
**Figure 1.** Sandia National Laboratories participants in the new Solid-State Lighting Science Energy Frontier Research Center.

**Figure 2.** Distribution of EFRCs geographically across the United States, by topical research area, and lead institution.