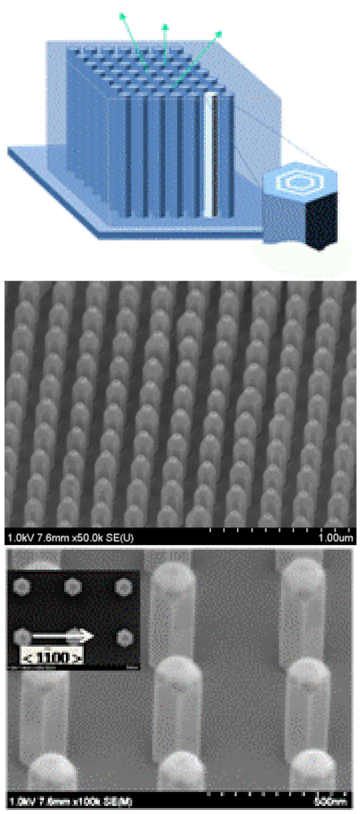
Center for Energy Nanoscience (CEN)
EFRC Director: P. Daniel (Dan) Dapkus
Lead Institution: University of Southern California

Mission Statement*: To explore the light absorption and emission in organic and nanostructure materials and their hybrids for solar energy conversion and solid state lighting.*

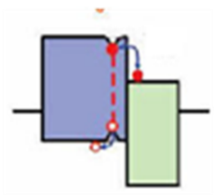


GaN / InGaN nanorods with nonpolar facets for LEDs. (top) schematic, (middle) GaN nanorod array, (bottom) close-up. of nanorods

The Center for Energy Nanoscience program to explore emerging materials in solar energy and solid state lighting has as its goals the invention of new solar cell and LED designs based on nanostructured and organic materials. This program is motivated by the following vision: ***to demonstrate new technologies based on novel nanostructure and organic materials that will enable photovoltaic energy conversion to become a significant portion of the world's electricity infrastructure and solid state lighting to become a dominant lighting technology in the world****.* To accomplish these goals, we have assembled an expert interdisciplinary team from four major research universities. This team has expertise in nanostructure synthesis, organic molecule and polymer design and synthesis, nanoscale and femtosecond optical and transport characterization of molecular structures and nanostructures, petascale simulations of materials structural, optical and transport properties and device physics, fabrication and characterization. This team will undertake fundamental studies in these areas to develop a broad understanding of the relationship between materials structure and composition and the ultimate device performance. From this understanding we expect new device designs will emerge that capitalize on our ability to engineer the materials at the molecular and atomic level in these systems. We envision nanostructured semiconductors, organic materials and the resultant novel device concepts to be assembled on low cost media, leading to cost effective implementation. Although the development of these cost effective processes is not part of the activities of the center, our researchers will be mindful of the eventual cost goals of the applications in their choices of materials and processes. We expect that the outcome of our research will be the rational identification and demonstration of designs for solar cells and LEDs that exhibit the performance goals we have identified as our targets.

The objectives of our research during the first five years will be to develop the fundamental control of materials and structures at the atomic/molecular scale, understand materials properties and processes at that level to permit the rational design of solar cells and LEDs based on these novel materials, understand interface and structural characteristics that control device performance, and discover the path to the fabrication of devices that demonstrate performance comparable to or exceeding current technology.

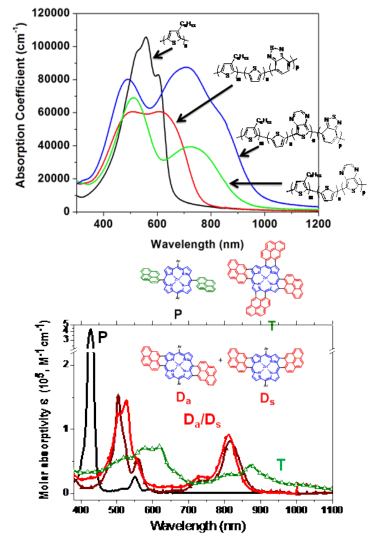
Our research plan capitalizes on the synergy that exists between emerging technologies for solar energy conversion and solid state lighting by conducting a program of research involving leaders in organic materials and devices and semiconductor nanostructure materials and devices in our Center to



Organic Heterostructure Solar Cell Schematic

exploit the opportunities that we believe will accrue by applying these new materials structures to both solar energy conversion and solid state lighting. We have identified materials technologies with the greatest long term potential to dramatically improve the performance and reduce the cost of solar cells and light emitters. Many of the technical and economic challenges that exist in both technologies can be addressed by adopting the philosophy underlying our program. The major challenge to the economical implementation of these technologies can be addressed by employing **high performance components** that can be fabricated in **thin structure designs on low cost substrates**. For this reason we have chosen to focus our efforts on **nanostructured semiconductor materials, organic materials and hybrid structures between them.** Organic materials can be deposited in nanometer thick films by solution or low temperature vacuum deposition methods on glass and plastic substrates to produce photovoltaic devices and light emitting diodes.

Similarly, nanostructured semiconductors can be *synthesized at low temperatures on low cost materials in structures* whose properties approach those of single crystal thin layers and whose characteristics can be **manipulated at the atomic level**. Given these characteristics, we believe that there is also an opportunity to explore hybrid structures between the materials that combine the best of both materials and may allow us to produce structures that exceed the performance of components using either one alone.



Broadened spectral absorption in polymers (top) and small molecule (bottom) organic materials achieved by rational design.

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