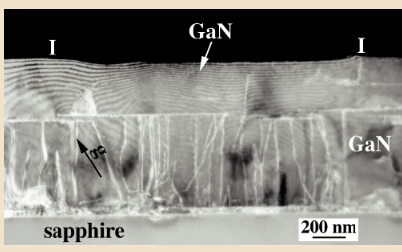
LBNL Capabilities in Solid State Lighting

Research and Development of Light-Emitting Diodes (LEDs) and Organic Light-Emitting Diodes (OLEDs)

Research & Development



Growing Low Defect GaN Crystals to reduce the density of structural defects

Research in LEDs

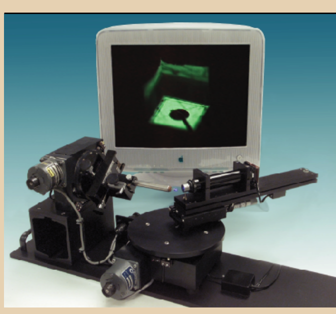
LBNL is one of the leading laboratories in GaN materials research. This ceramic material and its alloys with Al and In are the most promising semiconductor materials for solid state light sources. Blue, green, and white GaN LEDs are commercially available, but device performance must be significantly improved to compete with existing light sources. LBNL conducts research in collaboration with industry in thin film deposition and material analysis, which includes using the unique facilities of the NCEM and ALS (described below).


Spin casting of OLED

Research & Development of OLEDs

Researchers at LBNL are investigating both small and large molecule devices for general lighting applications. Although the technology holds the promise of high efficiency, significant technical barriers must be overcome before this technology achieves the necessary performance characteristics required by the lighting market. New materials and processes are under development to extend lifetime, improve the current, quantum, and extraction efficiencies, and reduce the costs of manufacture.

Optical Measurements

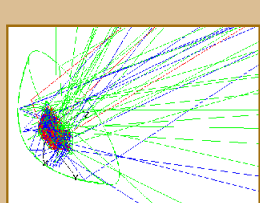
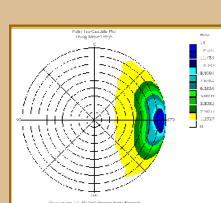

Minigoniometer viewing LED

The characterization of light sources for application in general illumination has been an ongoing activity of the Lighting Research Group at LBNL. Optical measurements are made to characterize the devices for radiant spatial distribution, spectral power distribution, total flux, and device efficiency and efficacy. The development of solid state light sources for general illumination requires the application of known techniques/technologies in new ways. For example, measurement of the spatial distribution of an LED is made with a mini-goniometer, pictured viewing an LED (left), and the spectral power distribution of an OLED is measured in an inert environment within a glove box (right).

Using these tools, LBNL is also working with industry to define the performance of the devices and to support activities which will improve that performance.


Measurement of spectral power distribution and efficacy of OLED

Applications

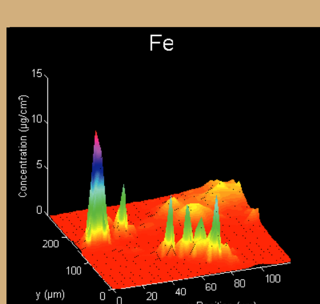


Optical design of device and packaging

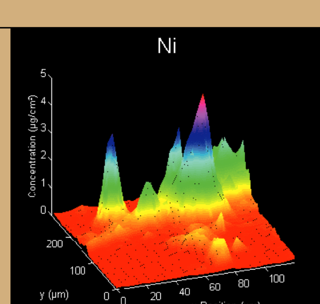
The application of solid state light sources offers new opportunities in the development of light distribution systems. Solid state sources offer flexibility to the end user not available with other sources, enabling control of intensity and color without negatively impacting product life. LBNL's Lighting Research Group is working with the most current technology in building automation and control, and will be applying these technologies to solid state lighting systems as they become available.


Design and fabrication of luminaires: LED porchlight

LBNL works with industrial partners to apply new technologies for maximum efficiency in light distribution systems. The small size of the LED permits optical design specific to a task, and the potential of OLEDs on flexible substrates permits molding of the light source to meet the requirements of the application. Whether it is the design of a reflector for an LED (left) or the integration of amber LEDs into an outdoor luminaire for residential applications (right), the objective is to accelerate the application of energy-efficient technologies in lighting.

Advanced Light Source (ALS)

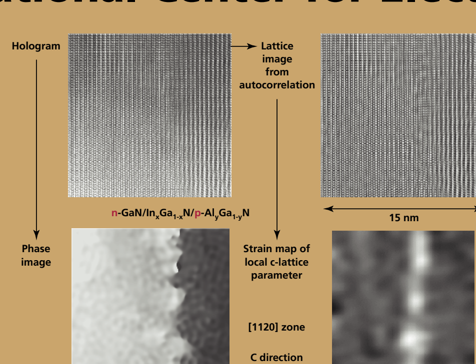




Fluorescence Microprobe Aids Development of Blue LEDs

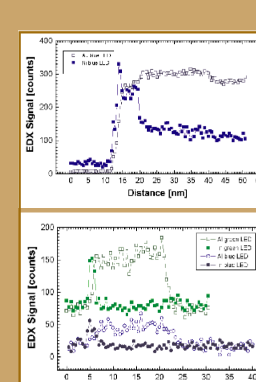
The semiconductor gallium nitride (GaN) has attracted widespread attention as a candidate for use in bright blue LEDs, laser diodes, and other devices that demand a wide electronic band gap. Its pure and intense blue completes the spectrum of available colors, making full-color LED-based displays possible. Researchers from Berkeley Lab's Materials Sciences Division are developing a preparation method for thick GaN crystals, using the Center for X-Ray Optics fluorescence microprobe to test the quality of the crystals they make. The images to the left show the spatial distribution of typical contaminants in a GaN sample as revealed by the microprobe. The researchers found that nickel and iron contaminants were highly mobile and had agglomerated along grain boundaries (boundaries between individual crystallites in the sample). Such groupings of contaminant atoms can cause short circuiting within a device. Having a clear view of what's going on inside the material will help the researchers to optimize the growth process to make high-quality GaN.

National Center for Electron Microscopy (NCEM)



Local Lattice Constants and Electric Fields LEDs

Electric fields and lattice parameters are simultaneously recorded by the side band and autocorrelation of an electron hologram. An inhomogeneous In distribution is typical for the LED structures. It largely affects the electric field. The average Indium concentration in the well is ~20%.



Local Lattice Constants and Chemical Composition in LEDs

EDX profiles of the active device area reveal critical parameters for the device performance, such as chemical composition and thickness of the metal contact to p-GaN. The light-emitting heterostructure is formed from InGaN and AlGaN. The relative intensity of the In and Al signal is similar in blue and green LEDs. Absolute composition, however, are often difficult to extract.

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