Nanostructured Electron-Injection Materials and Electroluminescence Method and Device

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BACKGROUND

Lighting is a major contributor to electricity consumption, accounting for 19 percent of global use and 34 percent in the U.S. The U.S. lighting market is currently dominated by the incandescent light bulb, which is only 5 percent efficient whereas the fluorescent lamp is 15 to 25 percent efficient. Solid-state luminaires, which are typically based on light-emitting diodes (LEDs), have the potential to revolutionize the industry with higher efficiency, better quality, and lower maintenance, possibly leading to a reduction of half the energy consumed by general illumination. For example, 30 percent efficiency has been achieved in a commercially available white LED and 50 percent in a laboratory white LED device. White light in such devices is produced either by combining light from different color LEDs or taking blue or near-UV light from an LED to "pump" a mixture of phosphors. The phosphor approach, when implemented with conventional phosphors, produces cold white light that is not color tunable and has non-optimal efficiency, but has the potential to overcome these shortcomings with the use of advances in materials.

The appreciable energy savings derived by converting from incandescent to fluorescent lamps and solid-state lighting has spurred government measures towards phasing out incandescent light bulbs. The general lighting market is predicted to exceed $130 billion by 2011 with the LED-based share forecasted to grow to $1.4 billion by 2012. There is clearly an unmet need and great market opportunity for new energy-efficient lighting devices.

TECHNOLOGY DESCRIPTION

UC San Diego researchers have developed nanostructured semiconductor phosphor materials and a method and device for producing light by injecting electrons into these new phosphors. The new device can potentially achieve a breakthrough efficiency of about 90 percent. In the invention, light results from electroluminescent emission that occurs with electron-hole recombination in the nanostructured phosphor. More generally, the invention's phosphors can emit light through one or more of the following mechanisms: photoluminescence, electroluminescence, and cathodoluminescence. The emission can cover the UV to IR region of the electromagnetic spectrum when different semiconductor materials and nanostructures are used. High brightness and high emission efficiency in the invention result from the sustained radiative recombination enabled by excellent charge dissipation (conductivity), large surface/volume ratio and large active recombination region, variety of heterostructures or superlattices, and improved light-extraction efficiency characteristic of the nanostructured materials. The nanostructure may take the form of quantum dots, nanowires, nanotubes, a branched tree-like nanostructure, nanoflower, tetrapods, tripods, and heterostructures. The choice of materials for nanostructure growth is broad and includes III-nitrides, III-arsenides and phosphides, II-VI, IV, and other oxide/chalcogenide semiconductors. The emission is typically UV/blue from wide bandgap materials, e.g., GaN, ZnO, etc., and green/red from narrower bandgap semiconductors such as InGaN, CdSe, AlInGaP, etc. Bandgap engineering allows tuning of the emitted color (UV, RGB, IR), color mixing (white), and color quality control (color rendering index and color temperature). Photoluminescent, as well as electroluminescent embodiments of the invention, can be implemented in various configurations to enable wide-range use in general illumination. Other applications include backlighting, signage, and specialty lighting.

STATE OF DEVELOPMENT

This invention has a patent pending and is available for sponsored research and/or licensing.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	8,847,476	09/30/2014	2009-075

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OTHER INFORMATION

KEYWORDS

compound semiconductors, nanowires, phosphors, electroluminescence, photoluminescence, solid state lighting, LED, incandescent bulb

CATEGORIZED AS

- **Energy**
  - Lighting
- **Nanotechnology**
  - Materials
- **Semiconductors**
  - Other

RELATED CASES

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