Solid Solution Phosphors for Use in Solid State White Lighting Applications
Tech ID: 25242 / UC Case 2010-022-0

BRIEF DESCRIPTION
A new green- and yellow-emitting phosphor material via solid solution that can be used to create a white light emitting diode.

BACKGROUND
Most currently commercially available LED lamps for generating white light employ yellow-emitting Ce\(^{3+}\) phosphors that are excited by blue InGaN diodes. However, these phosphors have relatively weak emission in the red region of the emission spectrum, which has led to limitations on their efficiency and color rendering ability. Additionally, the output color from Ce\(^{3+}\) phosphors is strongly dependent on temperature and current, which becomes a significant problem in high-power LEDs. Due to these limitations, there have been extensive efforts to develop new yellow-emitting phosphors for use in blue-pumped LED applications; therefore, a new phosphor material is required to increase phosphor efficiency and color-rendering property in the red region.

DESCRIPTION
Researchers at UC Santa Barbara have created a new green- and yellow-emitting phosphor material via solid solution that can be used to create a white light emitting diode. The phosphors created show a broad band emission from 430 to 760 nm when excited by existing InGaN-based blue LED and GaN-based long wavelength ultraviolet LED. LEDs that use the solid solution series phosphors are expected to have good color rendering properties with a wide spectral range and high efficiency for white lighting. The white light emission can be obtained using a wide variety of combinations of the new phosphor materials and blue or UV LED.

ADVANTAGES
▶ Good color-rendering property
▶ Variety of combinations of phosphor materials and blue LEDs
▶ Improved device efficiency

APPLICATIONS
▶ Solid state lighting systems
▶ Liquid crystal displays (LCDs)

PATENT STATUS

<table>
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<tr>
<th>Country</th>
<th>Type</th>
<th>Number</th>
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<td>United States Of America</td>
<td>Issued Patent</td>
<td>8,535,565</td>
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<td>2010-022</td>
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ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
▶ Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Subtrates
▶ High Efficiency LED with Optimized Photonic Crystal Extractor
▶ Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
▶ Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
▶ Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
▶ Defect Reduction in GaN films using in-situ SiNx Nanomask
- Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
- Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
- Hybrid Growth Method for Improved Ill-Nitride Tunnel Junction Devices
- Low Temperature Deposition of Magnesium Doped Nitride Films
- Transparent Mirrorless (TML) LEDs
- Laser Diode With Tunnel Junction Contact Surface Grating
- Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
- High Efficiency Semipolar AlGaN-Cladding-Free Laser Diodes
- Stand-Alone Ceramic Phosphor Composites for Laser-Excited Solid-State White Lighting
- Size-Independent Forward Voltage Micro-LED with an Epitaxial Junction
- Method for Enhancing Growth of Semipolar Nitride Devices
- Ill-Nitride Tunnel Junction with Modified Interface
- Improved Fabrication of Nonpolar InGaAs Thin Films, Heterostructures, and Devices
- Growth of High-Quality, Thick, Non-Polar M-Plane GaN Films
- Increased Light Extraction with Multistep Deposition of ZnO on GaN
- Selective-Area Mesoporous Semiconductors And Devices For Optoelectronic And Photonic Applications
- High-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices
- Incorporating Temperature-Sensitive Layers in III-N Devices
- Oxyfluoride Phosphors for Use in White Light LEDs
- Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
- (In,Ga,Al)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
- MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
- Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy
- Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
- Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDs
- Methods for Fabricating III-Nitride Tunnel Junction Devices
- Low-Droop LED Structure on GaN Semi-polar Substrates
- Contact Architectures for Tunnel Junction Devices
- GaN Interlayer Design to Fully Eliminate V-Pits from InGaN Pseudo-Substrates
- Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
- Photocatalytic Reduction of P-Type Semiconductor Heterostructures
- Semipolar-Based Yellow, Green, Blue LEDs with Improved Performance
- Growth of Semipolar III-V Nitride Films with Lower Defect Density
- III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- Improved Manufacturing of Solid State Lasers via Patterning of Photonic Crystals
- Tunable White Light Based on Polarization-Sensitive LEDs
- Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
- Growth of High-Performance M-plane GaN Optical Devices
- Packaging Technique for the Fabrication of Polarized Light Emitting Diodes
- Improved Anisotropic Strain Control in Semipolar Nitride Devices
- High Light Extraction Efficiency III-Nitride LED
- III-V Nitride Device Structures on Patterned Substrates
- Activation of P-Type Layers of Tunnel Junctions in Micro-LEDs
- Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration
- Method for Increasing GaN Substrate Area in Nitride Devices
- Nitride Based Ultraviolet LED with an Ultraviolet Transparent Contact
- Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy
- Single or Multi-Color High Efficiency LED by Growth Over a Patterned Substrate
- GaN-Based Thermoelectric Device for Micro-Power Generation
- Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning
- LED Device Structures with Minimized Light Re-Absorption
- Growth of Planar Semi-Polar Gallium Nitride
- Nonpolar (Al, In, Ga)N Quantum Well Design
- UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
- Defect Reduction of Non-Polar and Semi-Polar III-Nitrides
- Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-150)