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\textsuperscript{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\textsuperscript{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>
<td>09/17/2013</td>
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RELATED CASES
2010-022-0

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
▶ Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
▶ 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 III-Nitride Tunnel Junction Devices
Low Temperature Deposition of Magnesium Doped Nitride Films
Transparent Mirrorless (TML) LEDs
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
III-Nitride Tunnel Junction with Modified Interface
Improved Fabrication of Nonpolar InGaN 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
Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
Photoelectrochemical Etching 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 Patternning 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
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 Patternning
LED Device Structures with Minimized Light Re-Absorption
Growth of Planar Semi-polar Gallium Nitride
Nonpolar (Al, B, 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)
Suppression of Defect Formation and Increase in Critical Thickness by Silicon Doping
Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures
Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD