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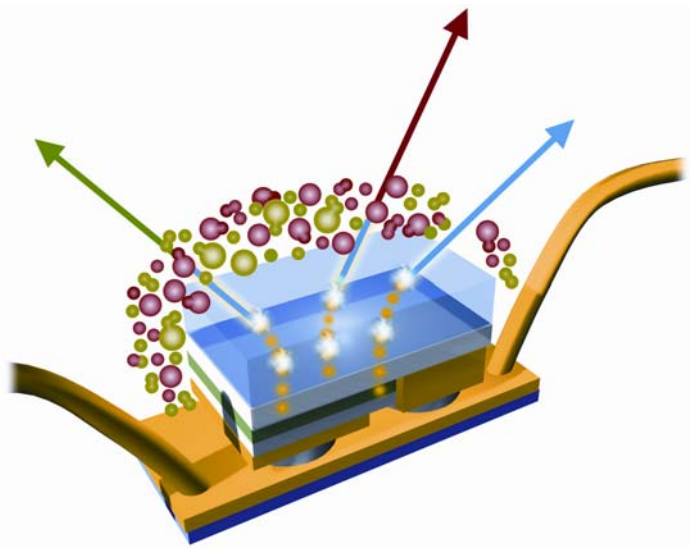
# White light out of the blue

The improving efficiency and output power of blue emitting nitride light emitting diodes (LEDs) has placed extreme demands on the performance of color-converting phosphors with which they may be combined to make white light. Many materials suitable for conventional lighting applications, such as those in Hg-based fluorescent lamps, are not useable under the specific conditions in LEDs. A recently discovered new family of rare-earth (e.g., Ce or Eu) doped nitride and oxynitride phosphors exhibits spectral characteristics well-matched to their III–V nitride semiconductor counterparts, as well as high quantum efficiency, chemical inertness, and high temperature stability. In a collaboration of researchers from Lumileds Lighting, San Jose, the Universities of Freiburg, Munich and Münster, and Philips Research Laboratories, Aachen, two orange-red and yellow-green phosphors are combined with a blue InGaN/GaN high power LED to yield a warm white (~3200 K) light source with high efficiency (25 lumen/Watt) and excellent color brilliance. The robust optical properties of the phosphors provide for extremely stable white light emission. These achievements mark another milestone in the development of LEDs towards applications in general lighting.



Artist's view of the 2-phosphor-converted-LED: On a copper slug and underneath a plastic lens a 'flip-chip' is soldered to metal contacts; 'flip-chip' meaning the substrate on which the stack of GaN and InGaN layers has been deposited is used as light exit, the (bottom) p-contacts being highly reflective. The color converting phosphors $M_2Si_5N_8$ (orange-red) and $MSi_2O_2N_2$ (yellow-green) (M = alkaline earth) are placed on top of the chip. Primary blue as well as down-converted red and green photons are emitted.

**See also:**
R. Mueller-Mach, G. Mueller, M. R. Krames, H. A. Höppe, F. Stadler, W. Schnick, T. Juestel, and P. Schmidt, phys. stat. sol. (a) **202**, 1727 (2005)
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