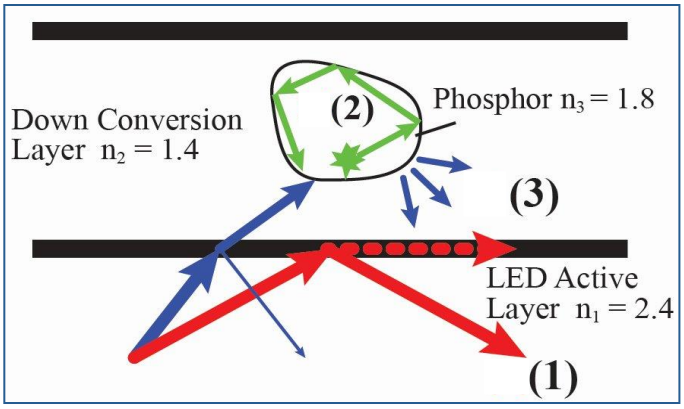
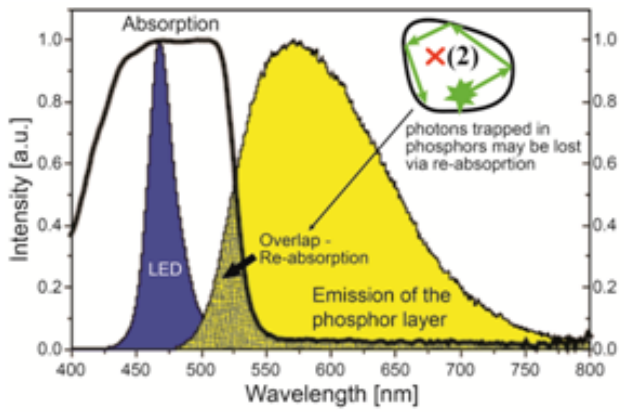
pixelligent

Silicone Nanocomposite Advantage

Most white LEDs are made by encapsulating a blue LED with a phosphor containing layer, which converts some of the blue light to red, green, and yellow to make white light. Because of the refractive index (RI) mismatch, light generated is unable to escape from the LED and phosphors, which is then reabsorbed, resulting in significant waste. The three most important mechanisms of light loss due to index match are shown in the left figure below: (1) Total Internal Reflection (TIR) caused by RI mismatch at the chip and phosphor down-conversion interface results in light to be absorbed and lost as heat; (2) at the phosphor-silicone interface light is trapped by TIR of the down-converted photons within the phosphors; and (3) at the phosphor-silicone interface light is scattered back to silicone or the active layer and absorbed. Another source of light loss is the emission and absorption spectra for a typical phosphor shown on the right figure. The overlap between the two spectra is another source of light loss. Reducing the RI mismatch between the phosphor and the binder will reduce the path length within the phosphor, reducing re-absorption.





These factors contribute to significant heat generation at the places in the device where heat is the most difficult to remove. This significantly increases costs for heat sinks and impacting device lifetimes. Pixelligent silicone-nanocomposites reduce the refractive index (RI) mismatch at these key interfaces allowing generated light to escape from the LED and phosphors.

Pixelligent's Silicone Nanocomposite Kits

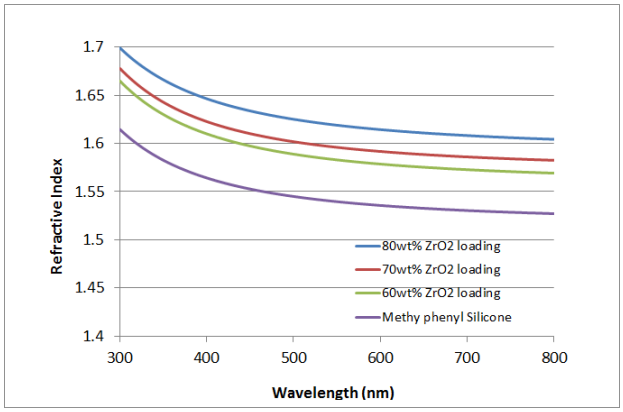
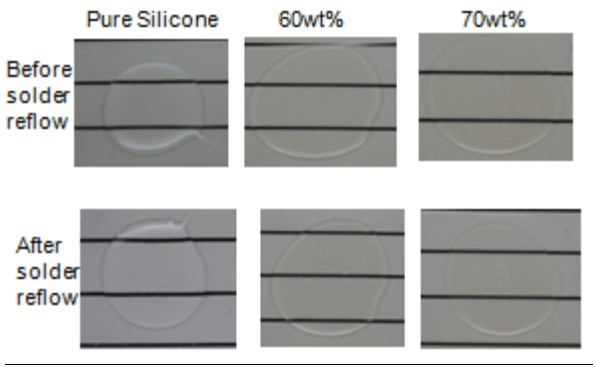
Pixelligent's advanced PixClear™ zirconia nanocrystals have been designed to raise the RI of commercial silicones used in LED packaging. Typical nanocrystals are poorly dispersed and highly agglomerated in silicones which translate into poor thermo-optical properties. Pixelligent's advanced manufacturing process allows control of the size, shape and purity of the nanocrystals which avoids these drawbacks. In addition Pixelligent has tailored the surface chemistry of zirconia nanocrystals to make it more compatible with silicones. These nanocrystals are available with the required silicone materials as LED silicone kits for testing and evaluation.

Two types of silicone kits available are: Phenyl Silicone Kit and Dimethyl Silicone Kit. Each kit consists of a ZrO2 nanocrystal dispersions in xylene, a silicone formulation, a catalyst and application notes. The silicone kits can be formulated and thermally cured following the procedure outlined in the application notes to provide a high refractive index zirconia-silicone nanocomposite.

The Phenyl Silicone Kit provides an optically clear zirconia-silicone nanocomposite film with 80 weight percent zirconia nanocrystal loading resulting in high RI of 1.63 at 450nm, high transparency of >90% in the visible range at 200 micron thickness and is thermally stable at temperatures ≥150°C.

The Dimethyl Silicone Kit provides an optically clear dimethyl silicone film with 80wt% loading of zirconia nanocrystal. The dimethyl silicone film has a high RI of 1.58 at 450nm, high transparency of >90% in the visible range at 200 micron thickness and is thermally stable at temperatures ≥150°C.

Typical properties of the Cured Silicone Kits

Wavelength dependent RI for Phenyl Silicone Kit with 60, 70 and 80 wt% loading of ZrO_2	Optical Images for thermally cured 200 micron thick films with Phenyl Silicone Kit before and after solder reflow.
	

Wavelength dependent RI for Dimethyl Silicone Kit with 60, 70 and 80 wt% loading of ZrO_2	Optical Images for thermally cured 200 micron thick films with Phenyl Silicone Kit before and after solder reflow.