LED Package Reliability
(Color Point Stability)

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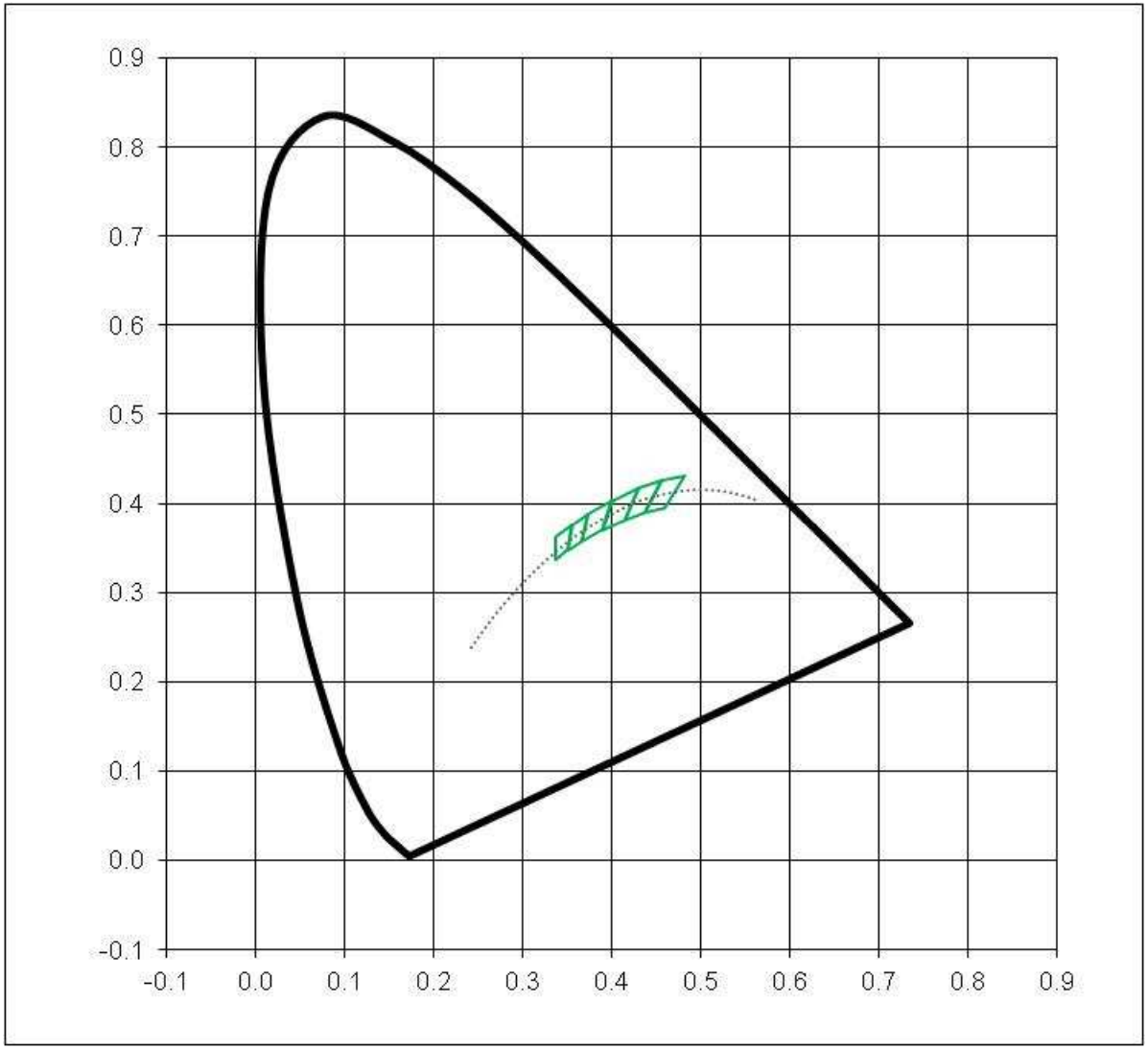
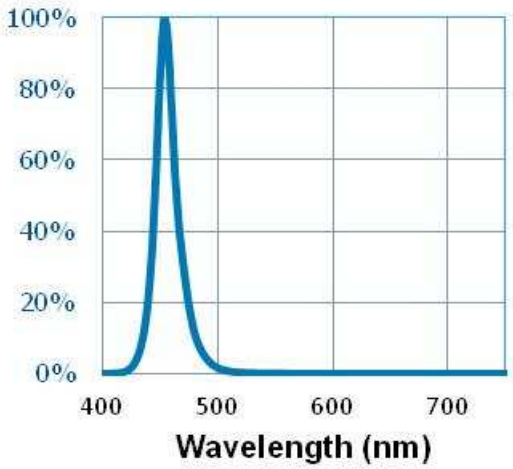
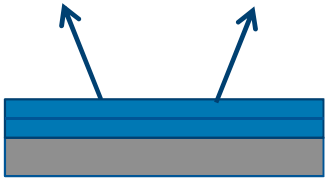
CIE 1931 Color Space

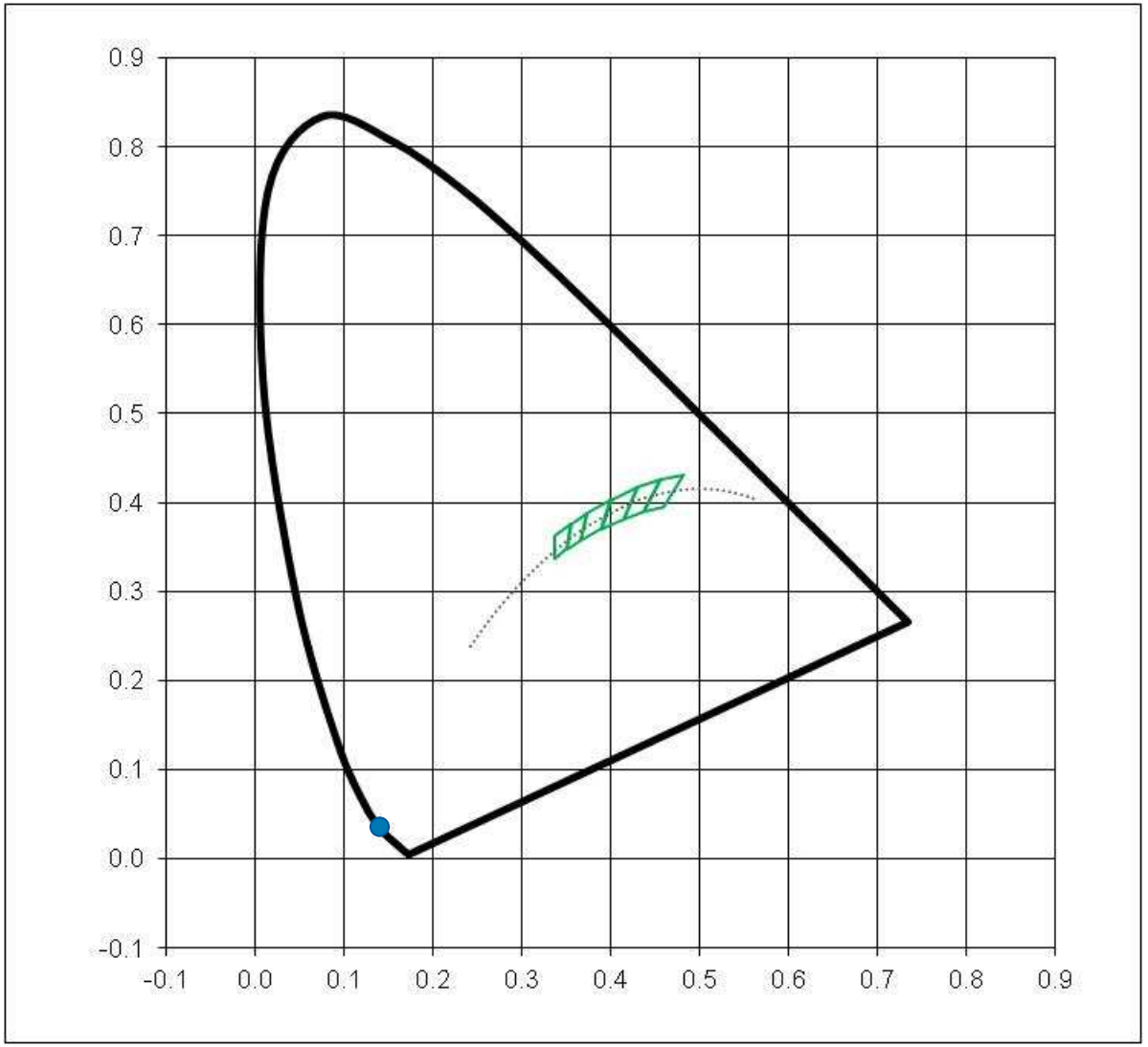
ANSI C78.377
Color Bins Shown



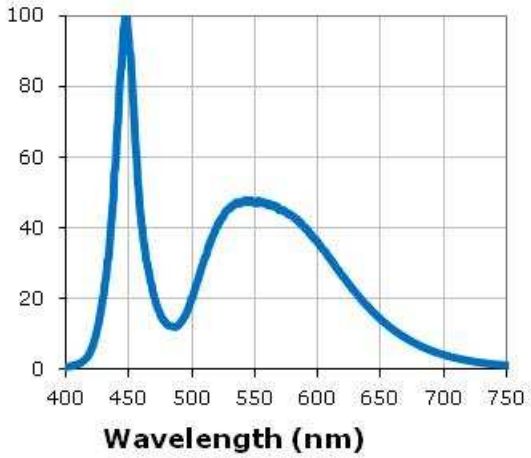
CIE 1931 Color Space

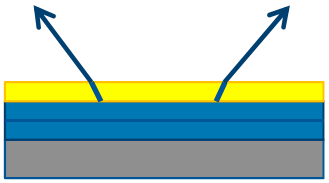


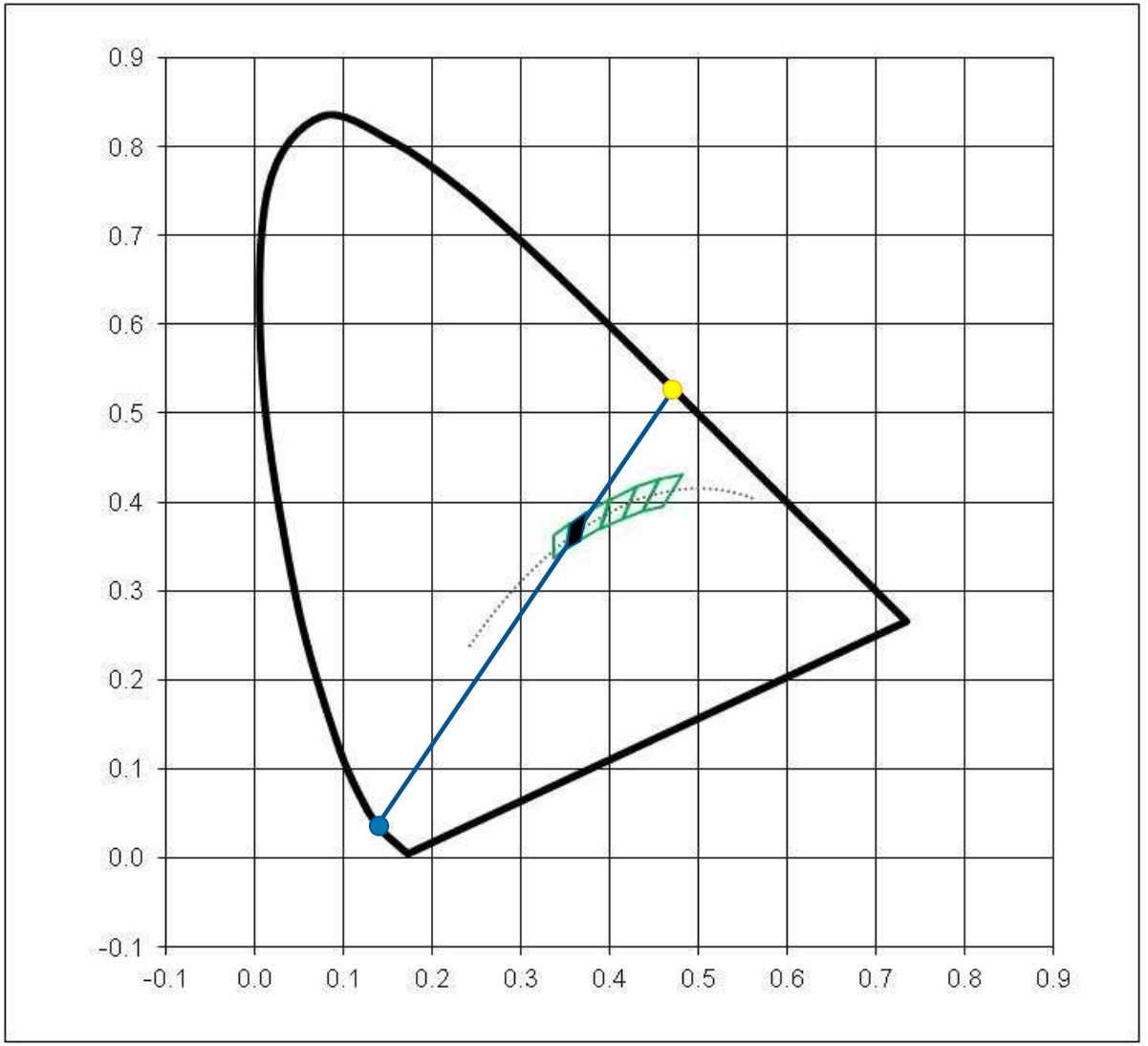




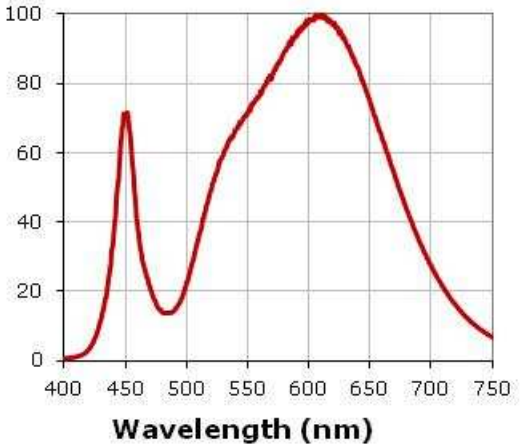
CIE 1931 Color Space

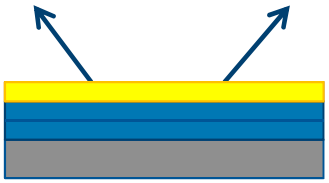


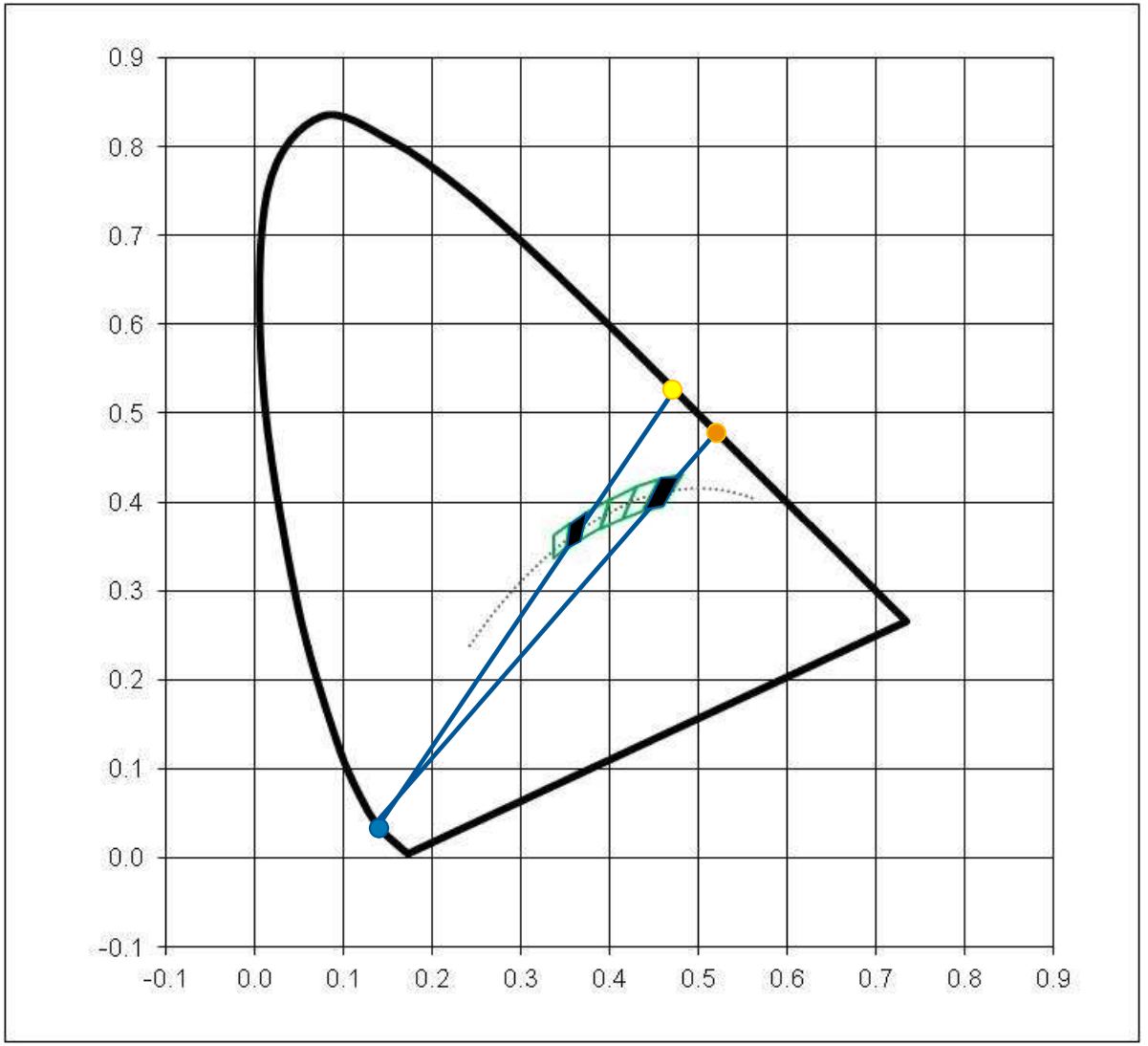




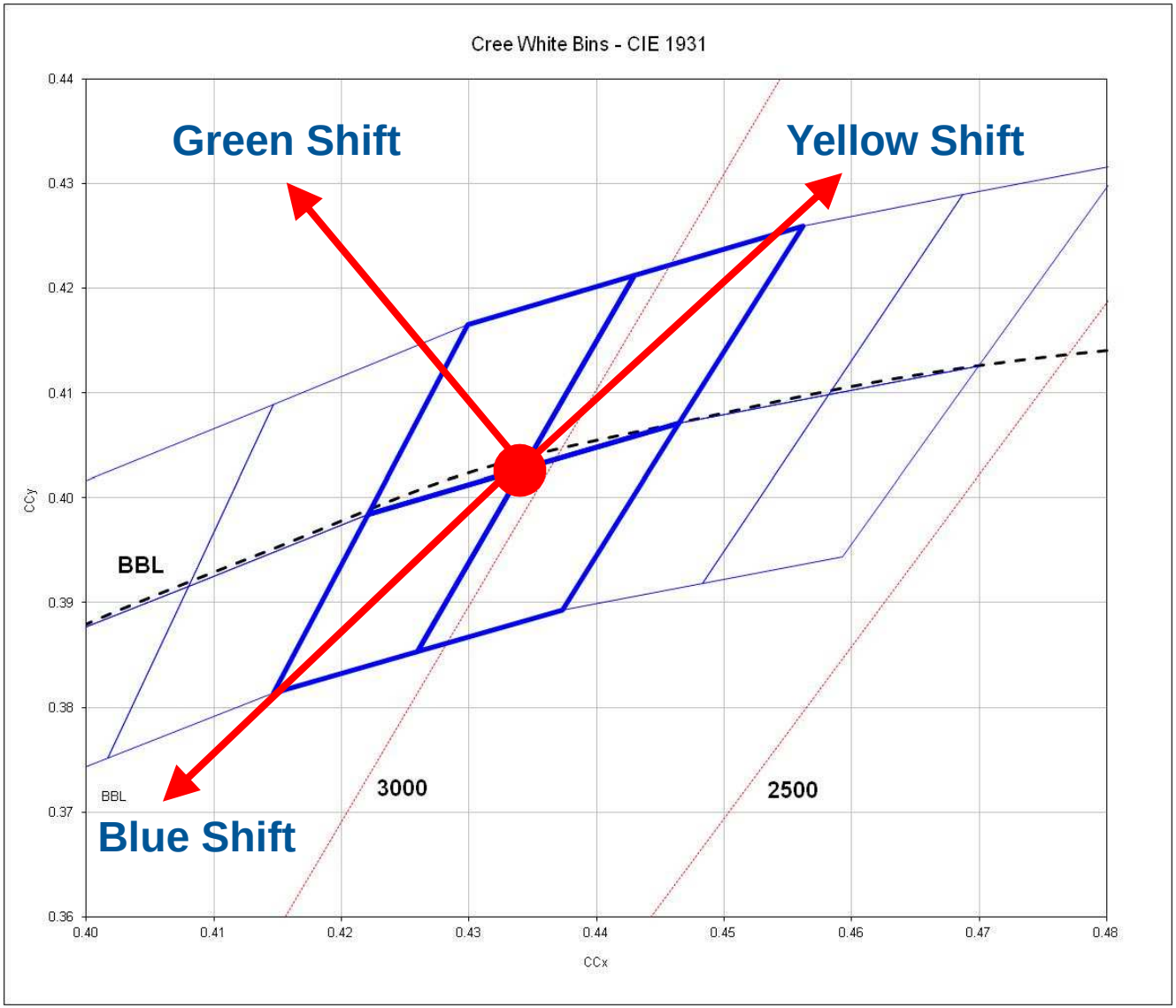
CIE 1931 Color Space







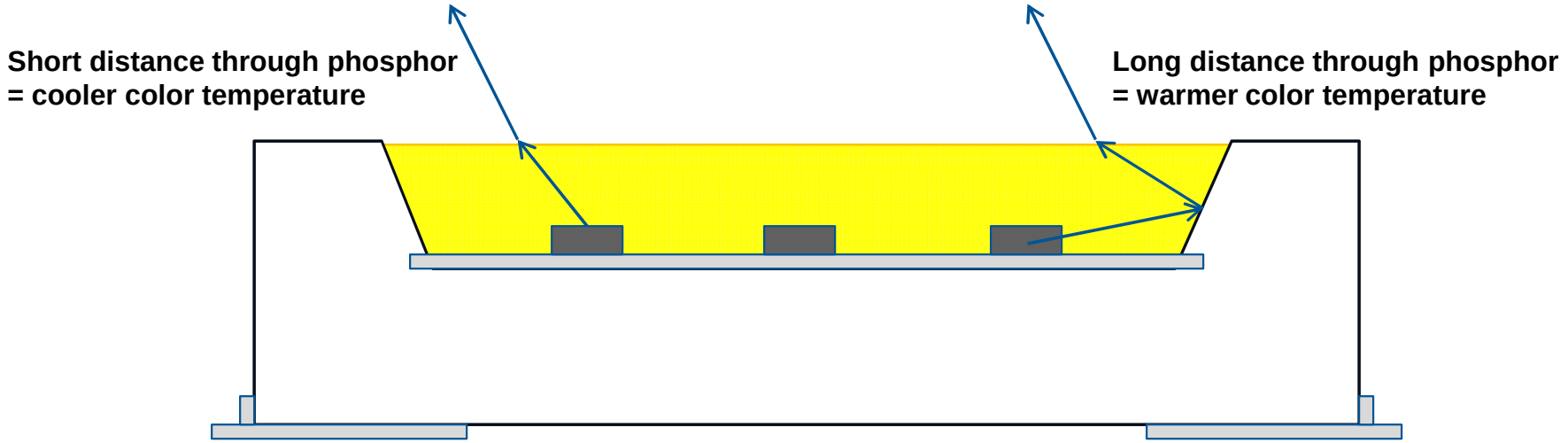
Observed Color Shift with LEDs



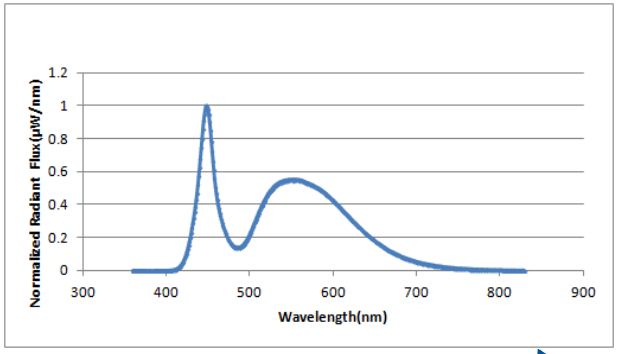
Color Shift with Plastic Packages

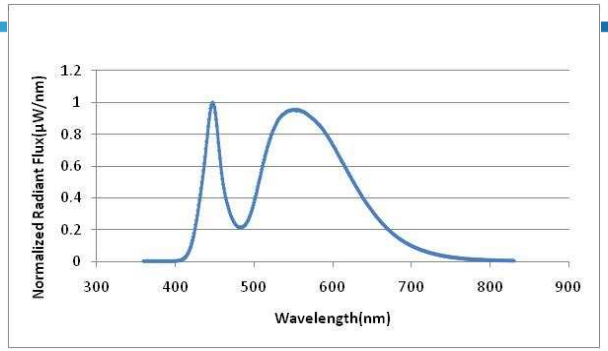
The white material in the package cavity reflects much of the light emitted from the LED chips.

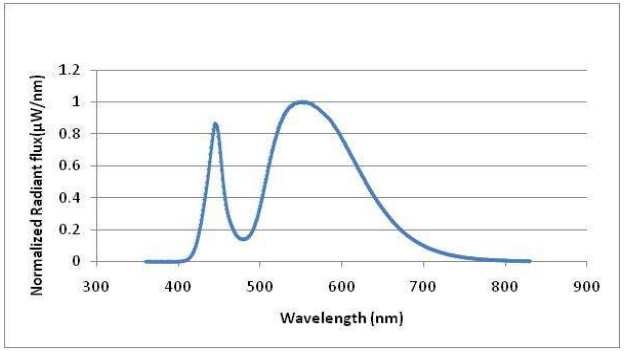
The overall chromaticity (color) of the LED is a combination of all of the light emitted directly from the chips through the phosphor and that which is reflected internally in the package.



Color Shift with Plastic Packages

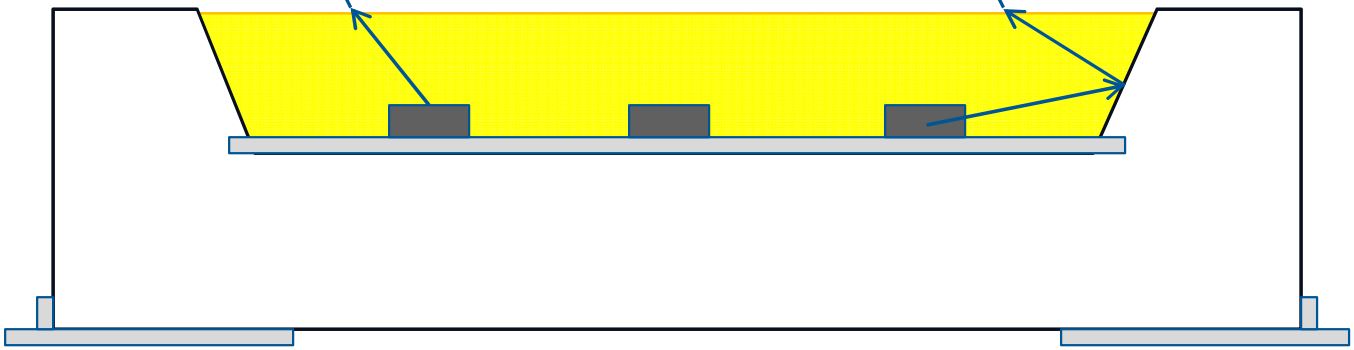




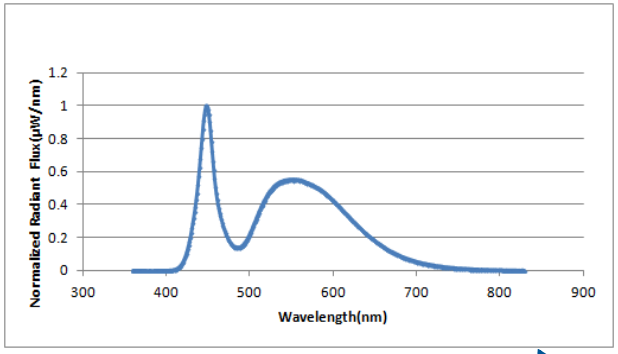


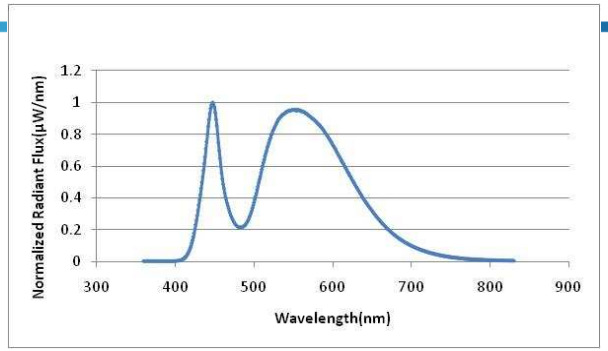
Short distance through phosphor
= cooler color temperature

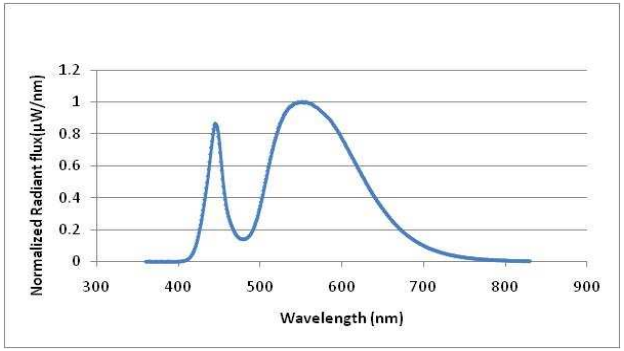
Long distance through phosphor
= warmer color temperature



Color Shift with Plastic Packages

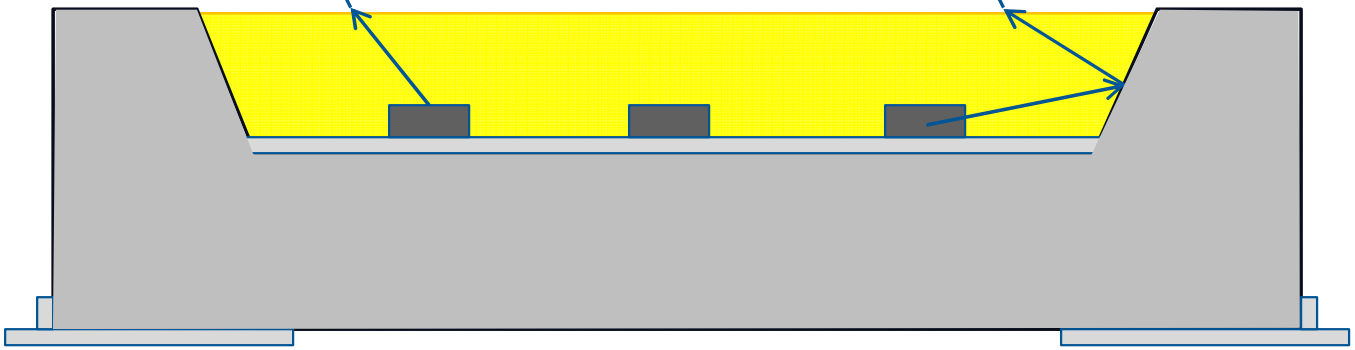






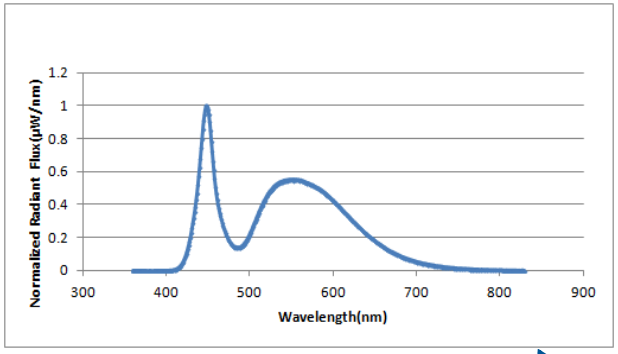
These photons will continue to be emitted from the package

These photons will not be reflected off the package walls.



Over time the materials in these packages will discolor.

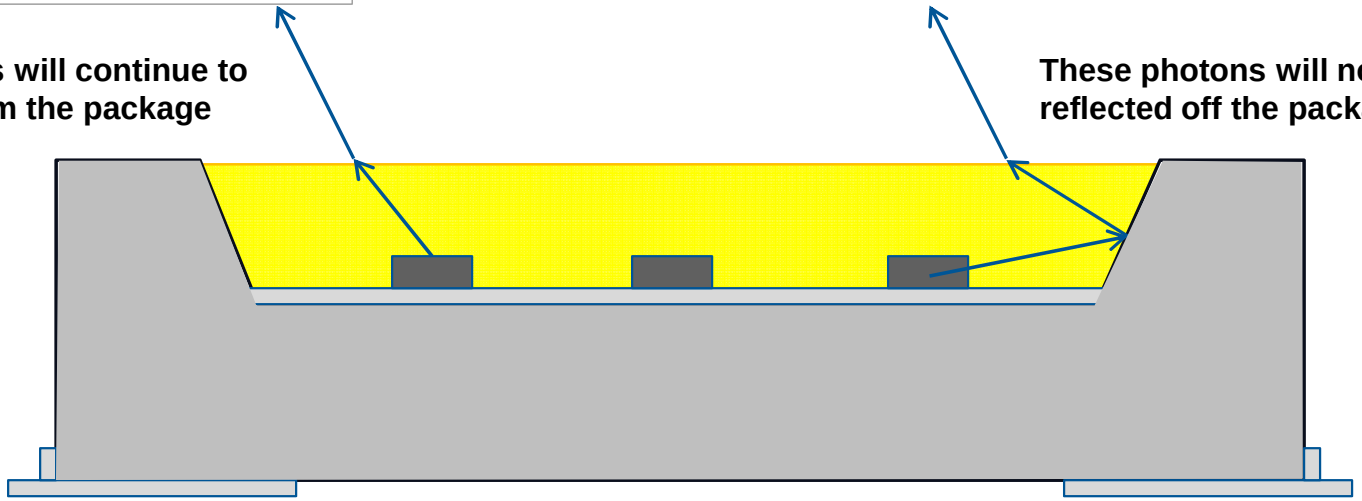
Color Shift with Plastic Packages



An overall blue shift and lumen depreciation results

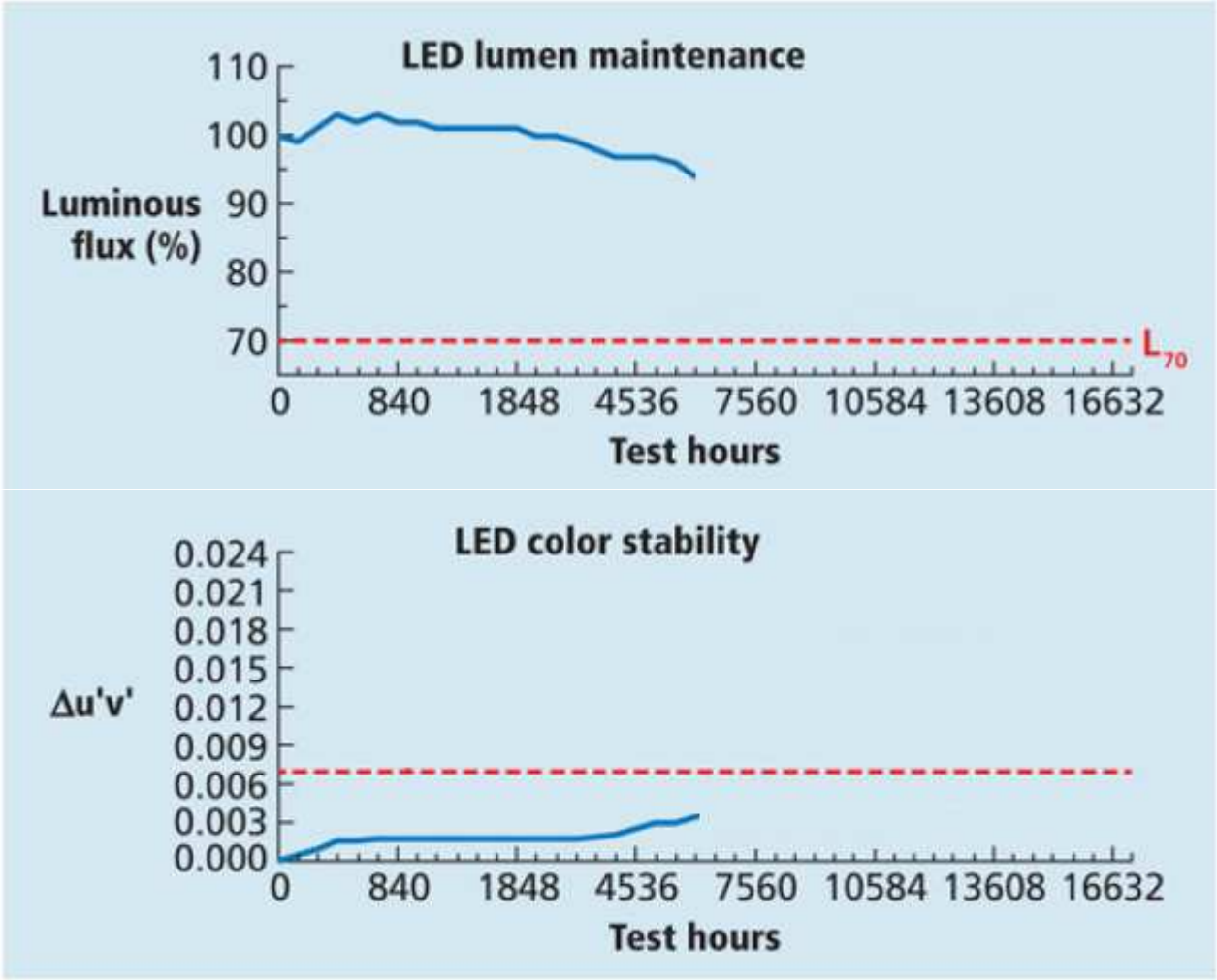
These photons will continue to be emitted from the package

These photons will not be reflected off the package walls.



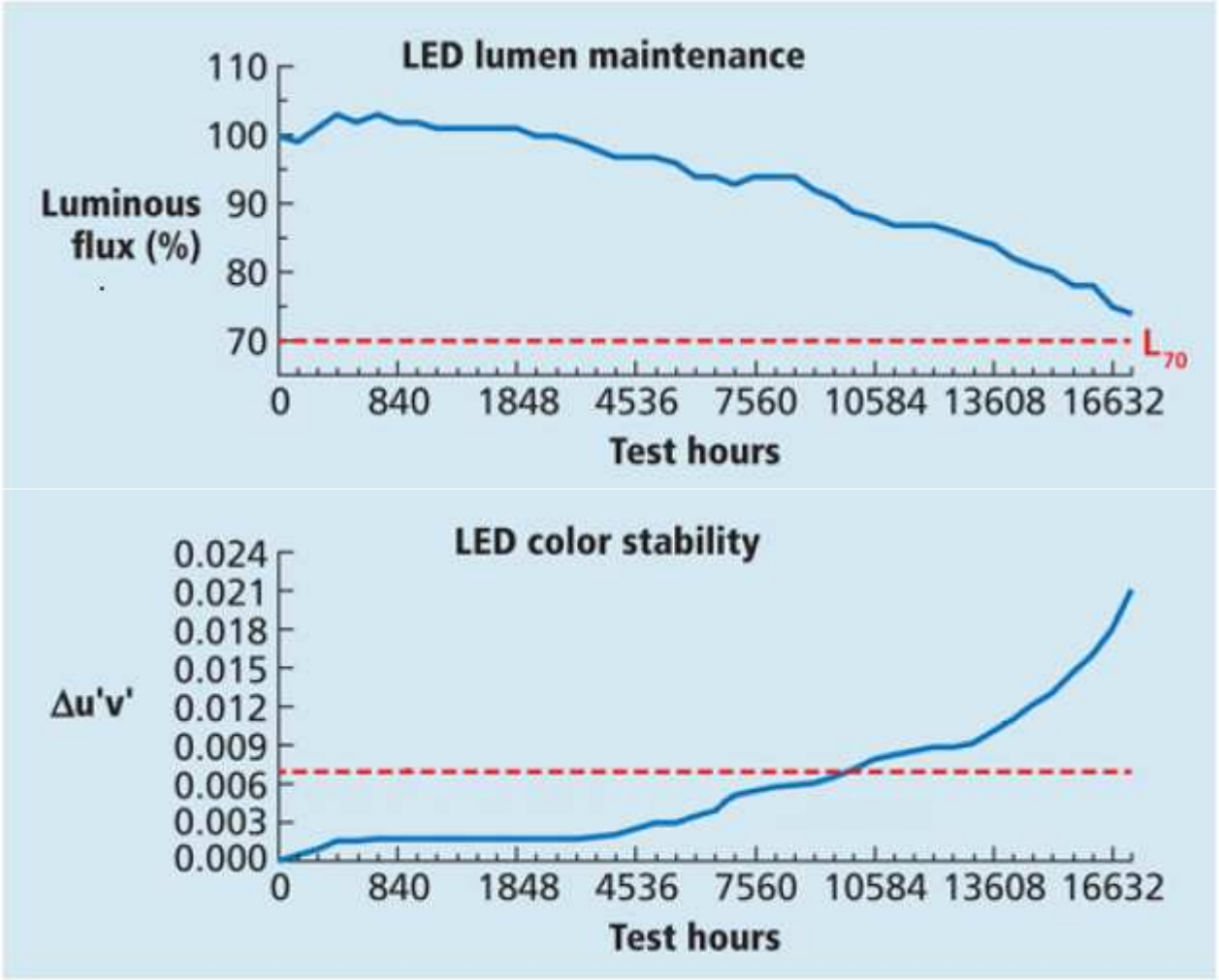
Over time the materials in these packages will discolor.

LM-80 Test – PPA Plastic Packages



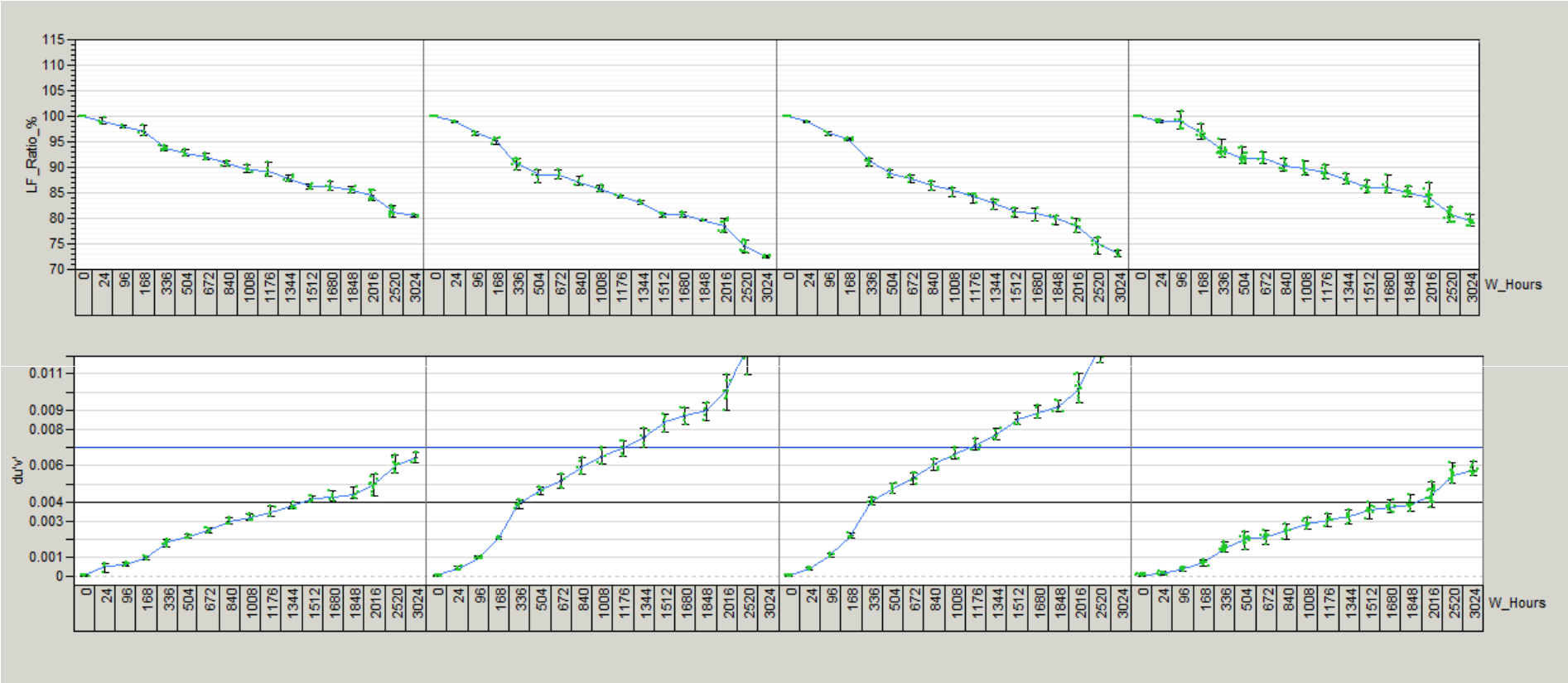
Tsp = 85ºC

LM-80 Test – PPA Plastic Packages



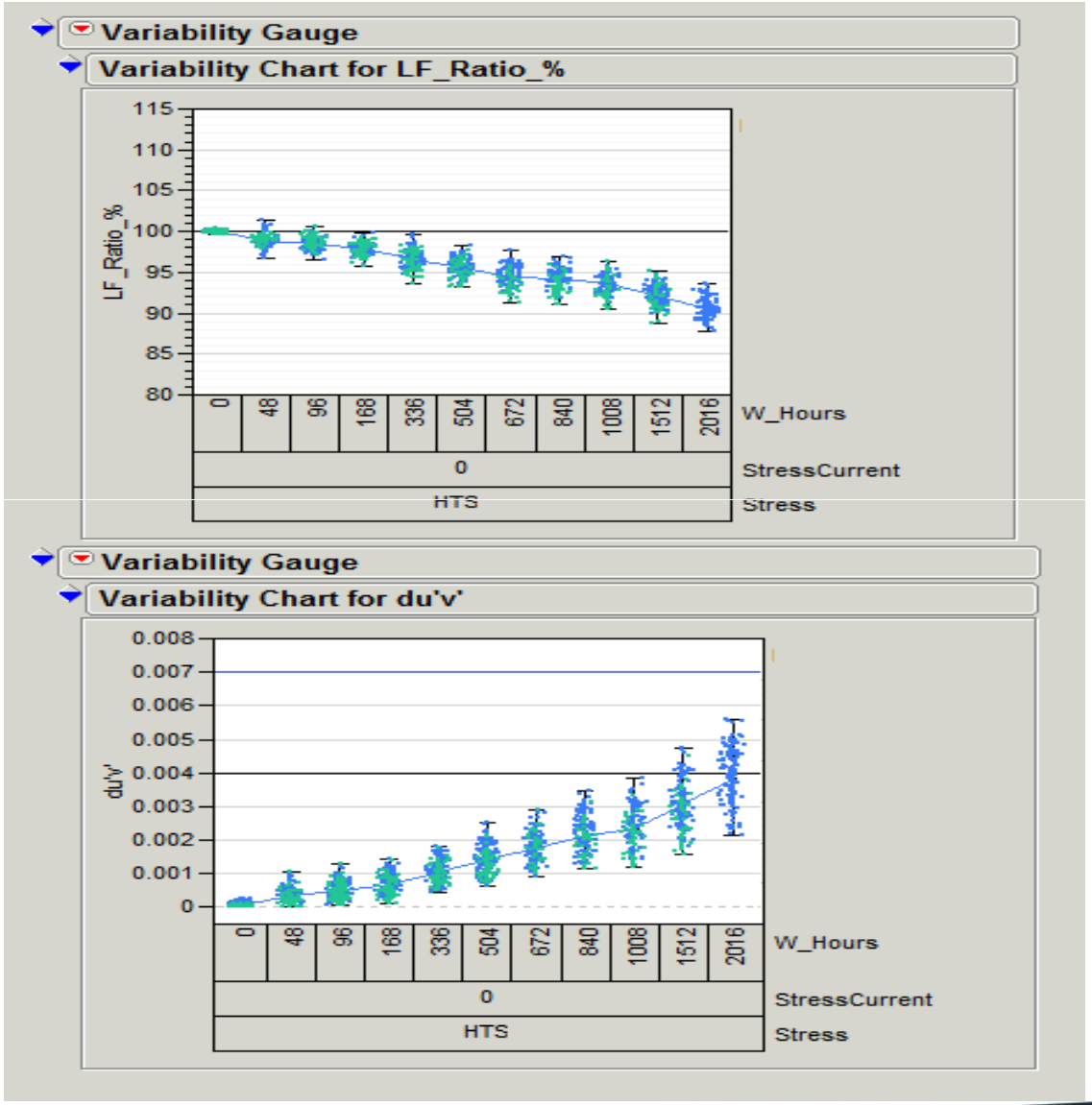
Tsp = 85ºC

Storage Test – PPA Packages

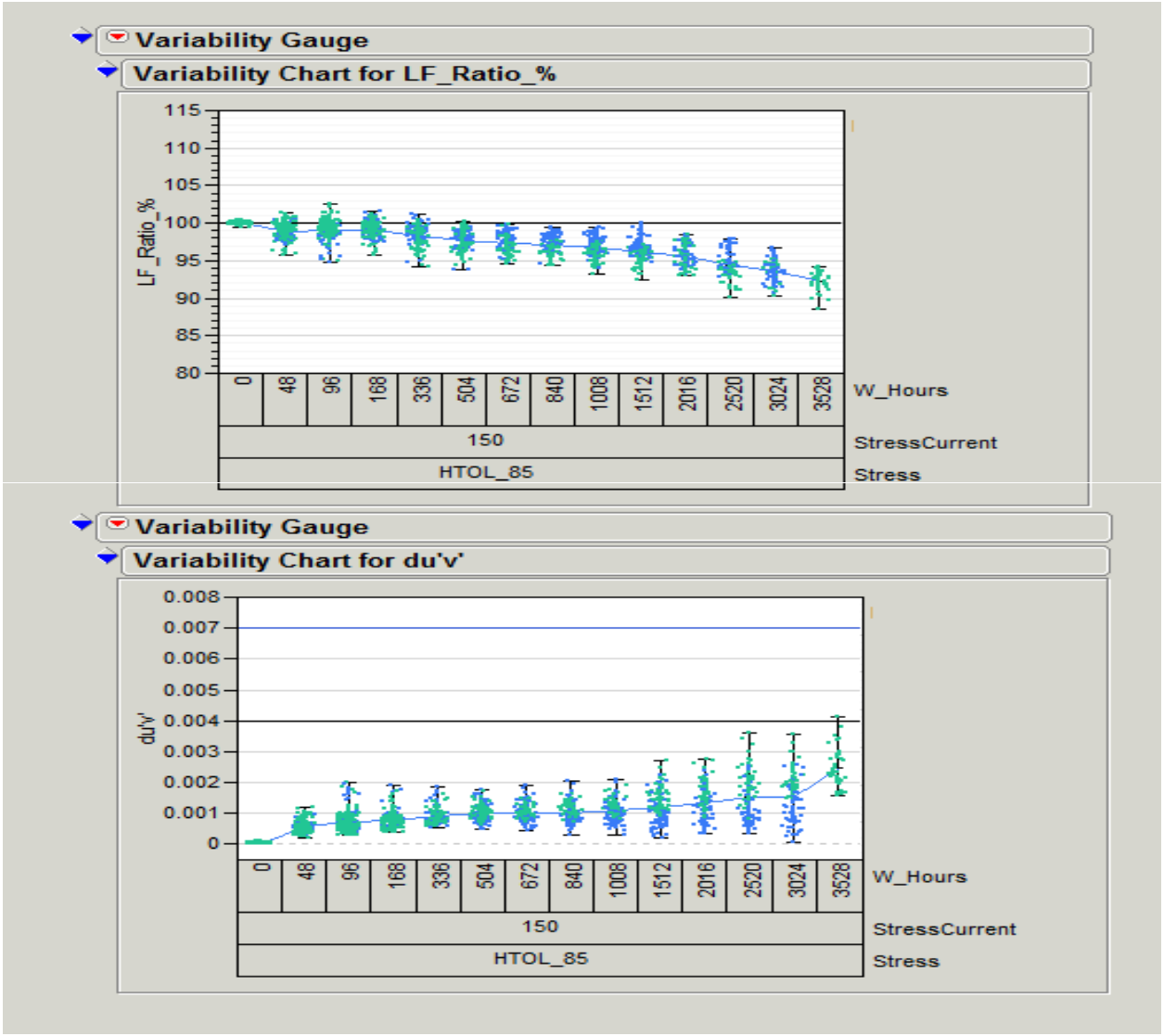


LEDs placed un-powered in reliability test chamber.

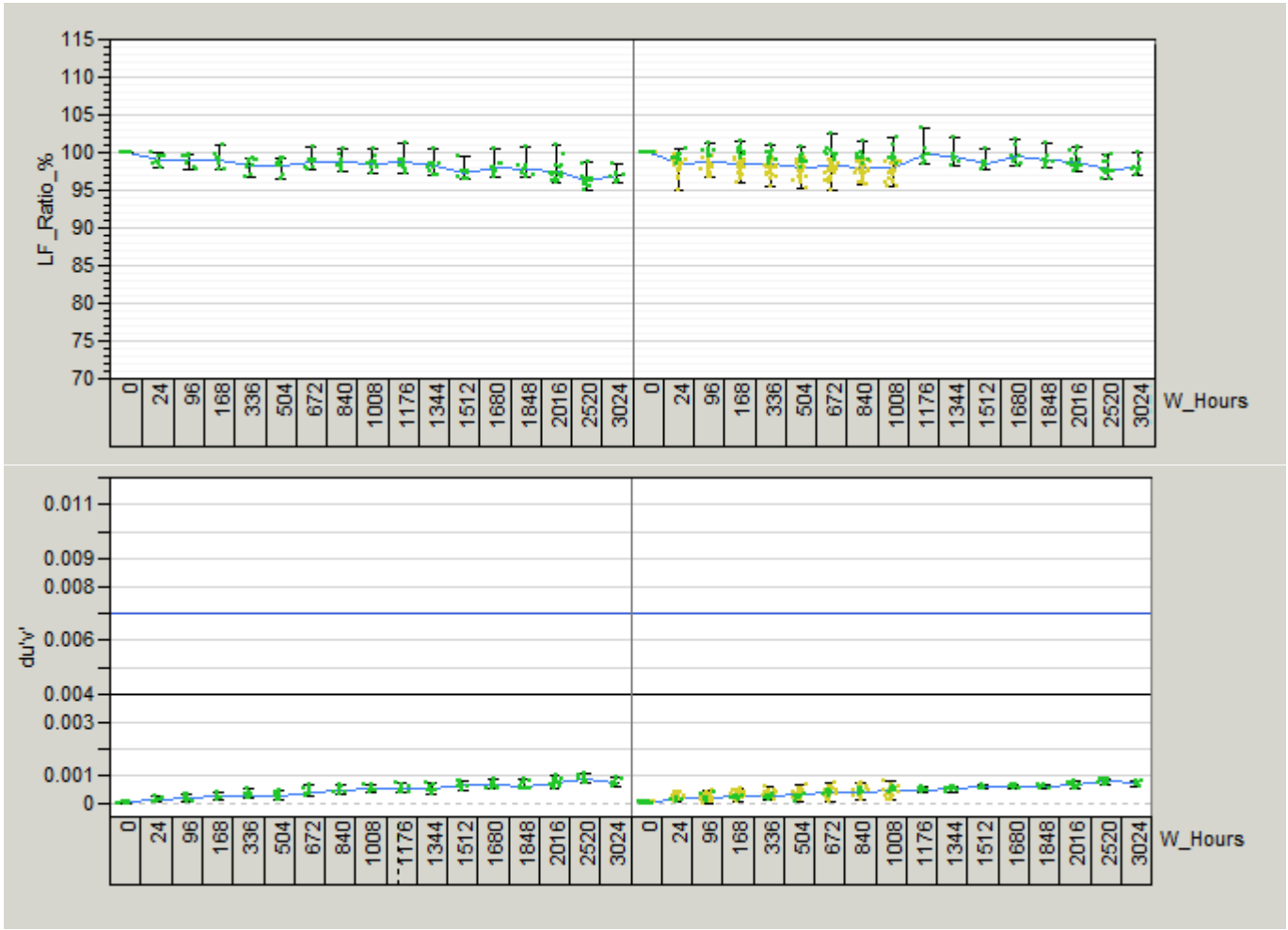
Storage Test – EMC Packages



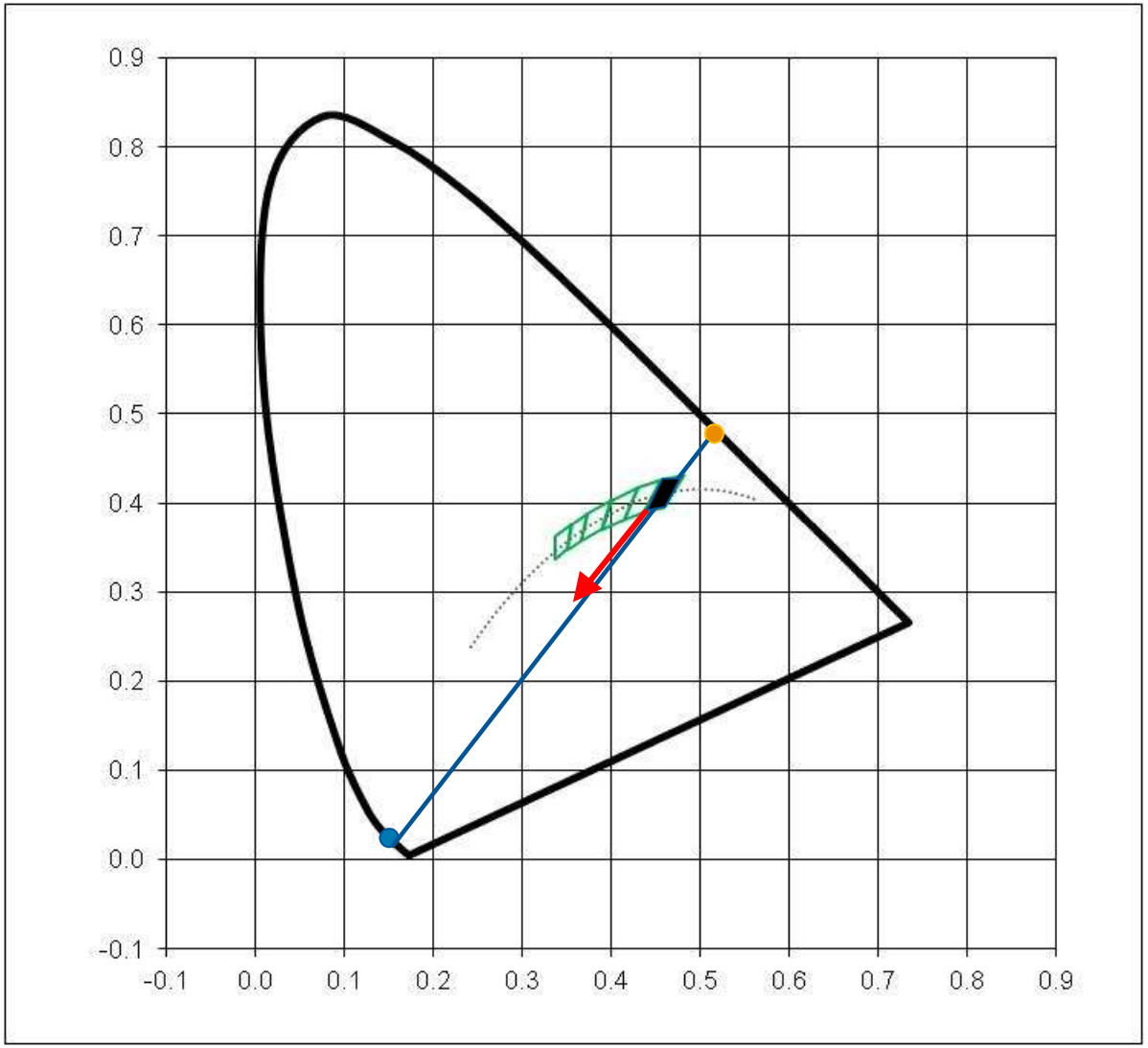
LM-80 Test – EMC Packages



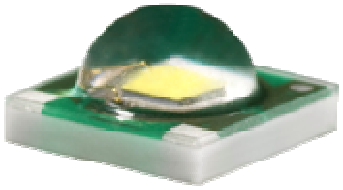
Storage Test – Ceramic Packages

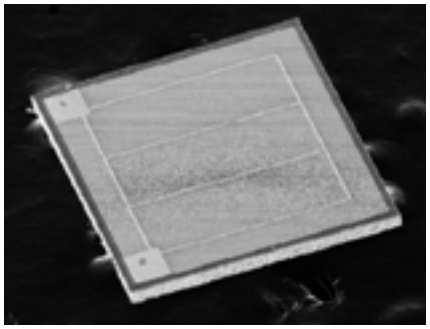


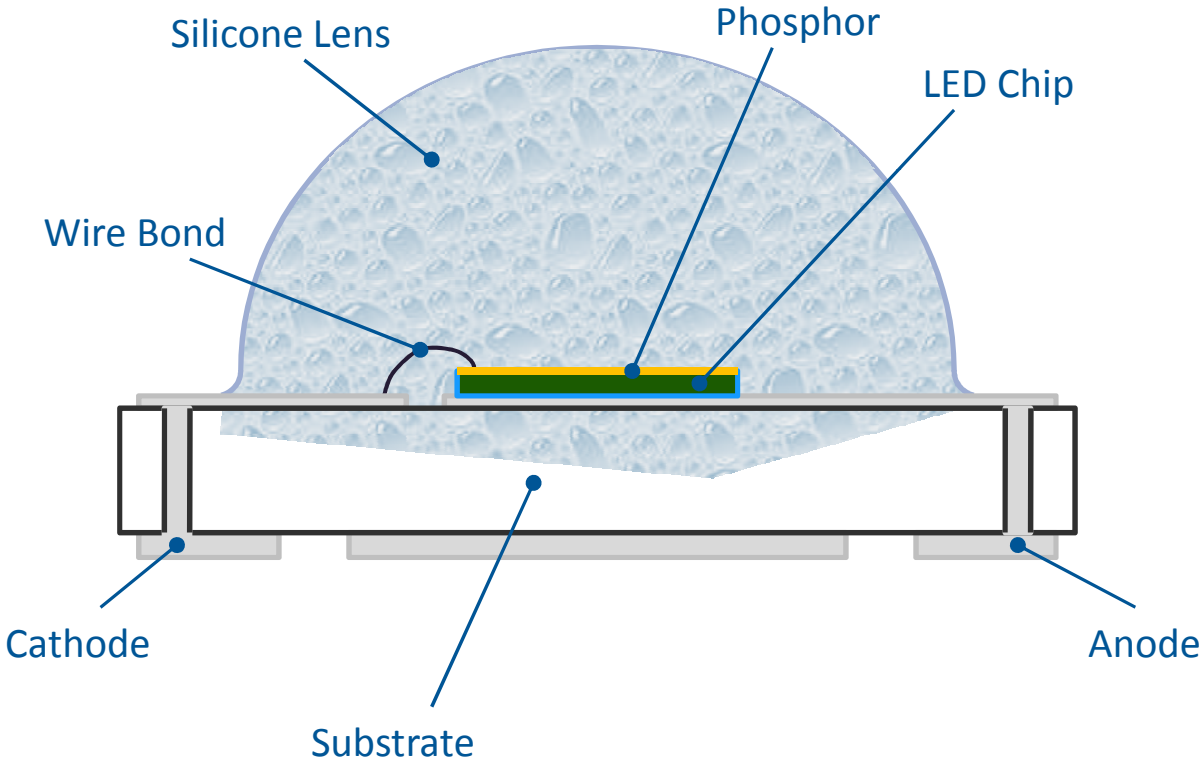
Blue Color Shift with Plastic Packages



Phosphor Chip Coated LED







Phosphor Chip Coated LED (High Temp Operation)

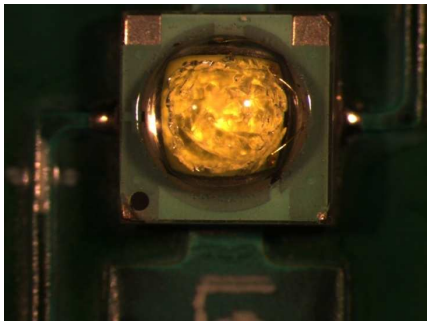
A. Normal LED appearance – Phosphor layer is uniform across the LED Chip surface as LM-80 testing starts.

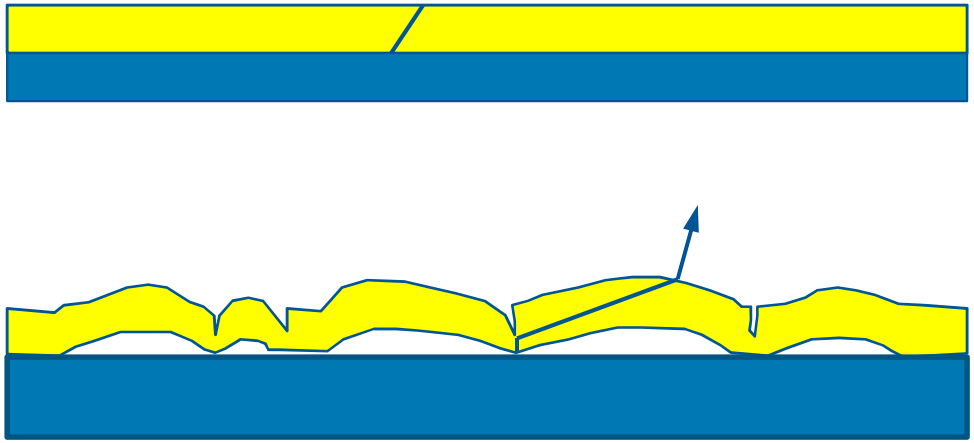
B. Delamination of the phosphor from the surface of the chip begins.

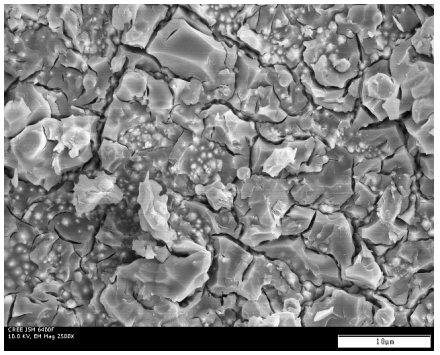
C. Severe delamination and cracking of the phosphor layer.

Phosphor Chip Coated LED

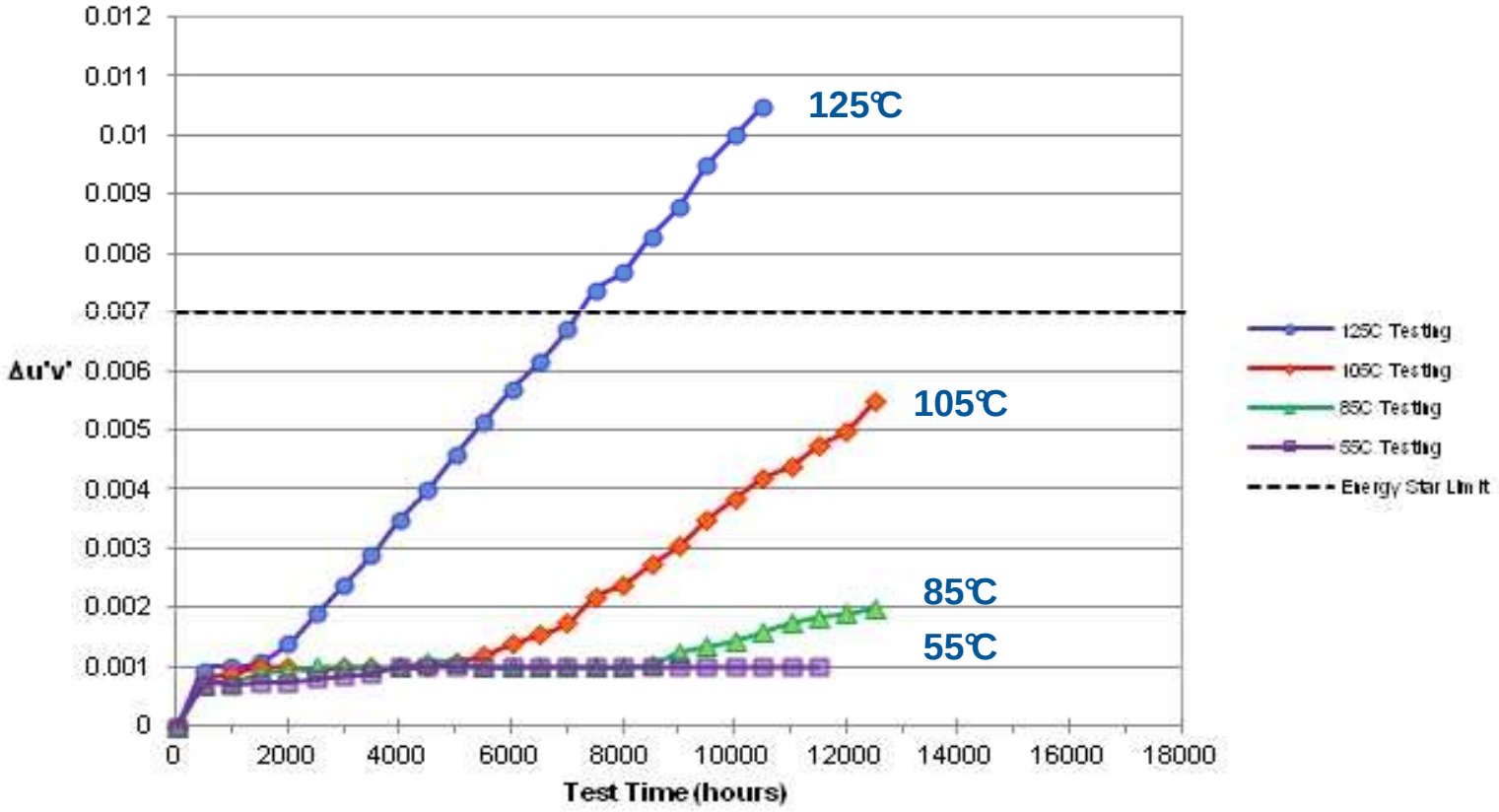
At high temperatures cracking and delamination of the phosphor can occur at the chips surface. The light scattering increase in the angle at which the emitted light travels through the phosphor. The path of the blue photons through the phosphor is increased causing a shift towards the warm end of the spectrum.



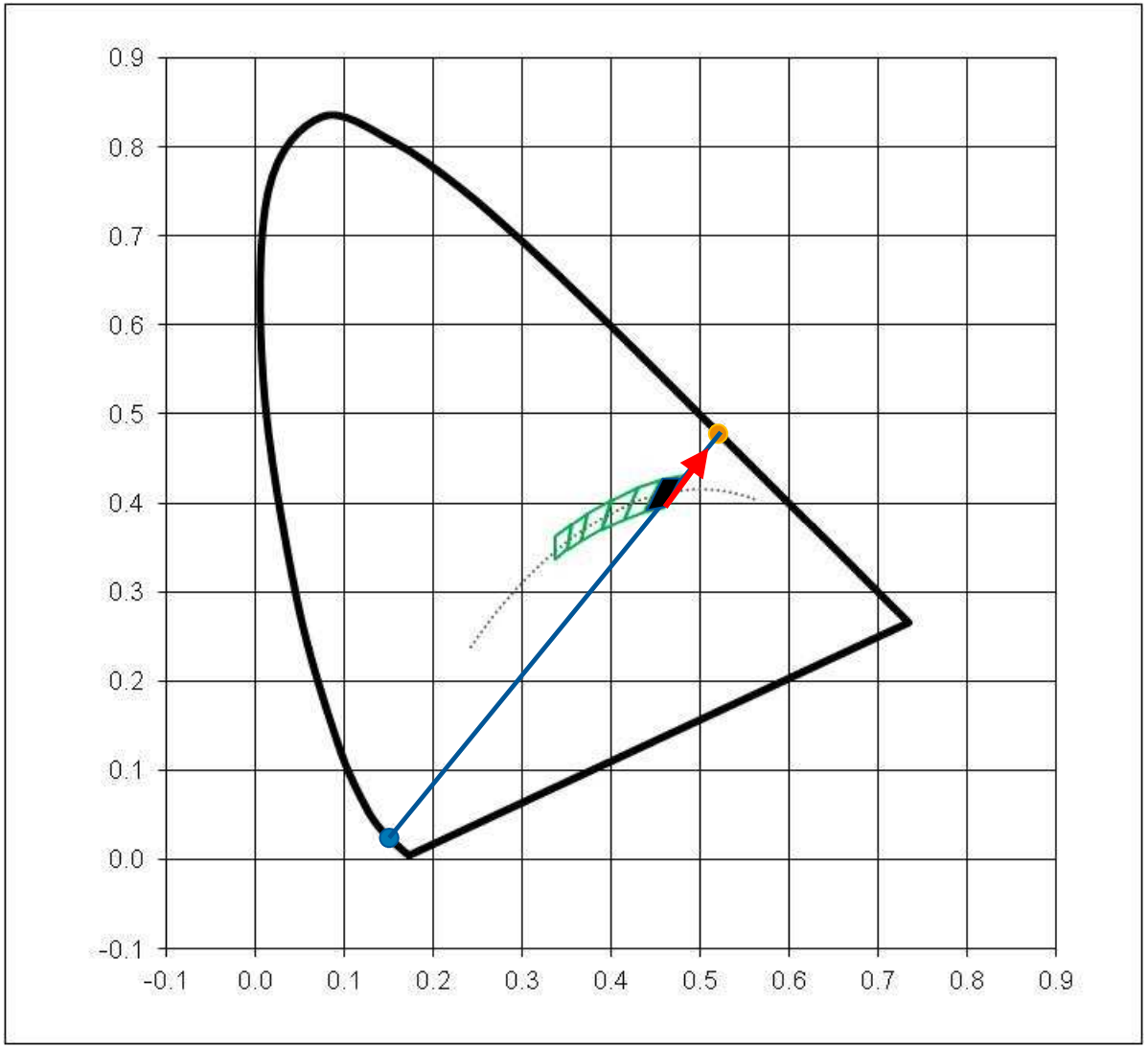




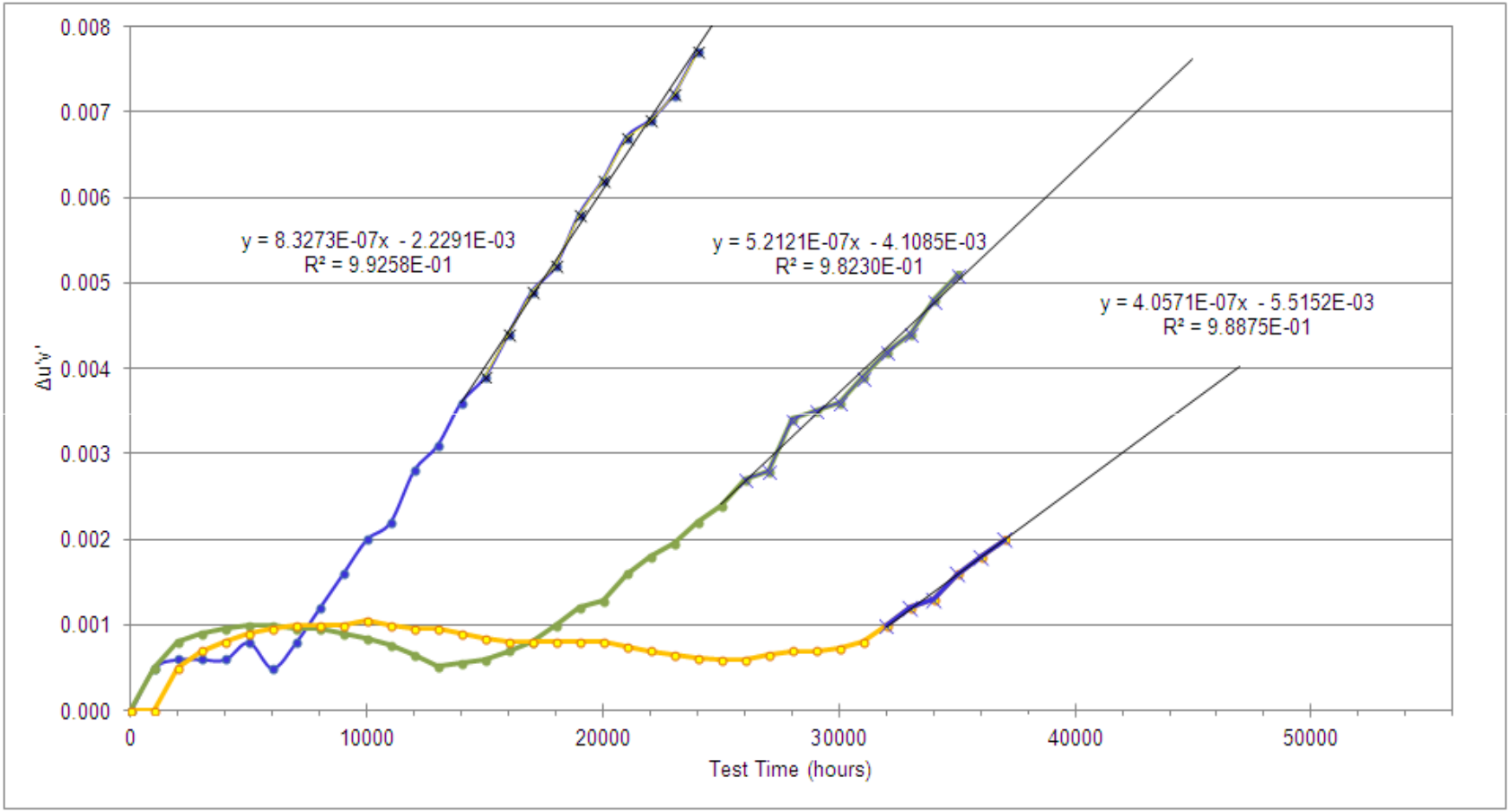
High temperature LM-80 testing has been used to accelerate the color shift in high power LEDs.



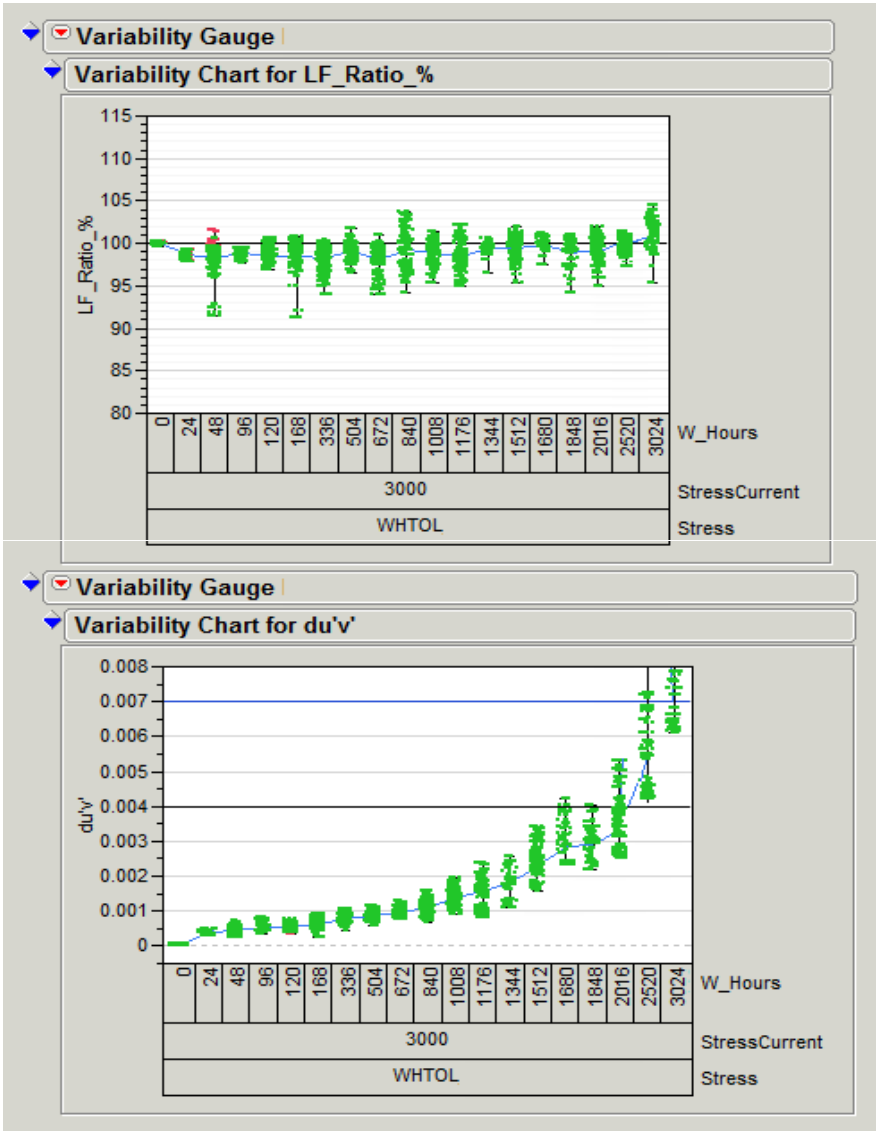
Yellow Color Shift



Can models be developed to project color shift over time?



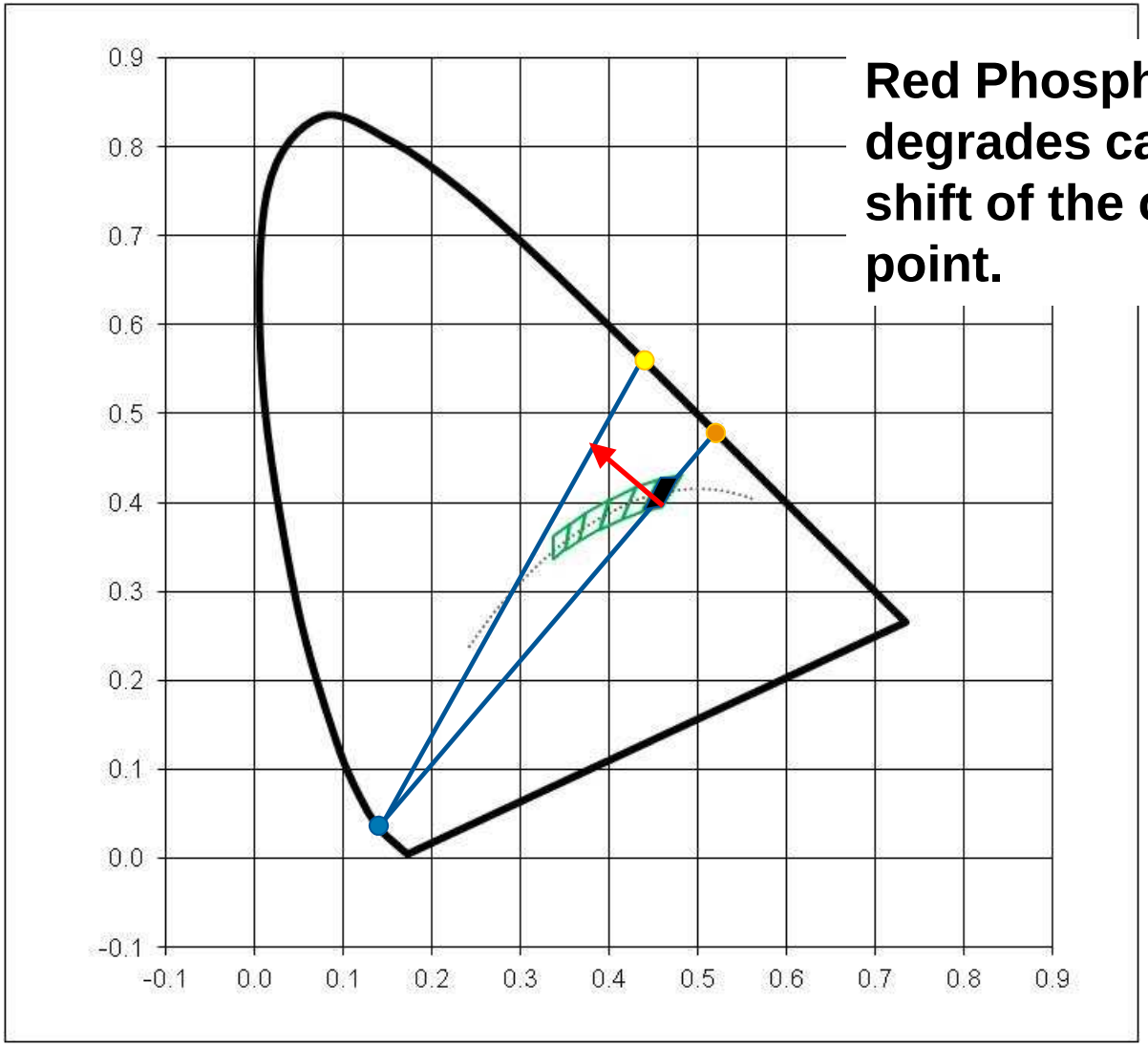
Color Shift during WHTOL testing



60/90 WHTOL Testing

Tsp = 60ºC
Tair = 60ºC
90% RH
1 hour on
1 hour off

Green Color Shift



Red Phosphor degrades causing a shift of the color point.

Summary

- **Color shift can happen with LEDs.**
- **There are many applications where it is not critical.**
- **There are many applications color point stability is important.**
- **Materials used in LED package construction will result in different color point stability characteristics.**
- **There is no method currently available to project color shift.**