Optical measurements and ray tracing simulations of LED luminaires with a diffuse ceramic reflector

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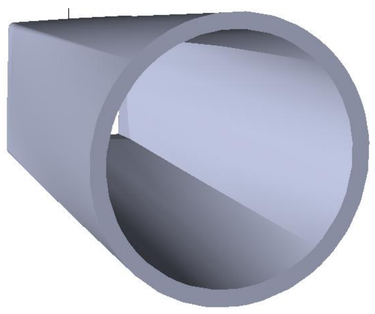
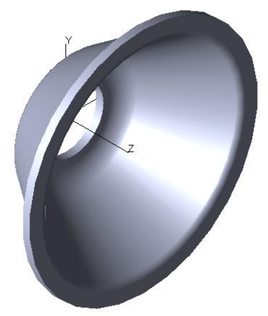
Objective

- Learn how the optics of luminaires with diffuse reflectors works
- Validate a Monte Carlo simulation model by comparing simulation results with experimental data

The luminaires

- Two simple luminaires with diffuse reflectors are studied
- For each luminaire the same light source is used
- The radiation pattern (light curve) for each luminaire is experimentally determined
- The optical characteristics of the light source and the reflector material are experimentally determined
- A geometric model incorporating the optical characteristics of the components is constructed in the ray tracing software package TracePro®



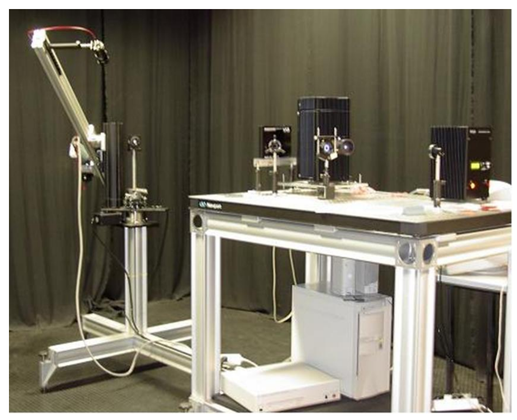


Modeling the light source

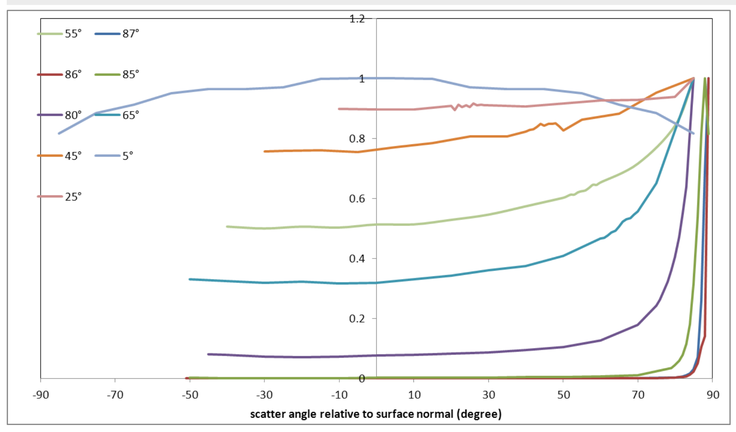
- Light source: LED N42180 (Seoul Semiconductors)
- Optical characteristics measured with a near field goniophotometer (RiGO 801)
- The LED is modeled with an optical source model (a ray file) based on the near field data (i.e.: not a geometrical model)

Characterization of the reflector material

- Ceramic material with a high reflective ceramic optical coating (CerFlex Tech® coating)
- Total reflection: 96%
- Claimed to be a diffuse Lambertian reflector
- The Bidirectional Reflection Distribution Function (BRDF) of the material is measured at a large number of angles of incidence
  - At small angles of incidence the BRDF is practically constant as expected for a Lambertian reflector
  - At large angles of incidence (65° and larger) the reflection pattern is completely different: the light is mostly reflected into a pattern resembling a Mohawk haircut

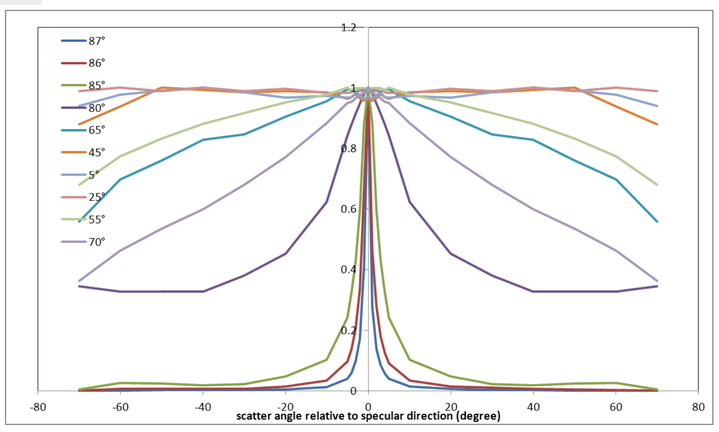


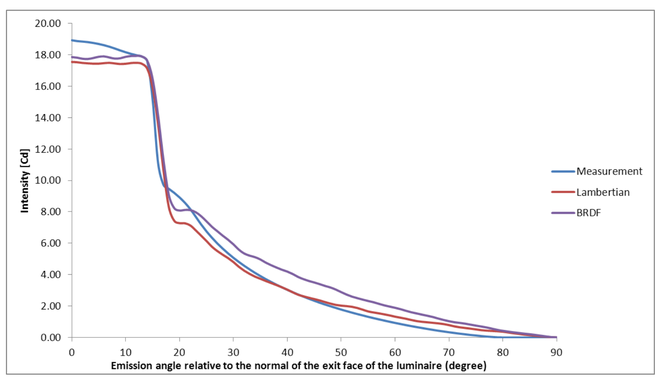
BRDF measurement set up

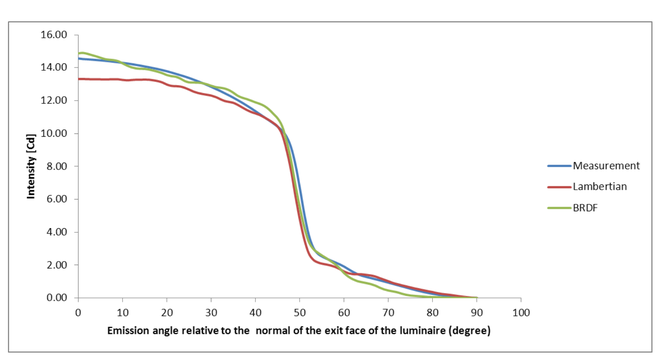


Left: normalized BRDF in the plane of incidence for a number of angles of incidence

Right: normalized BRDF perpendicular to the plane of incidence relative to the specular reflection direction







Comparison experimental data and ray tracing results

- The measured radiation pattern of the luminaires is compared to the radiation patterns found from ray tracing simulations
  - Ray tracing session with Lambertian reflector
  - Ray tracing session with BRDF data as reflector property
- Top left: radiation pattern of the long pipe like reflector
  - At large emission angles the Lambertian model predicts the radiation pattern best
  - At small emission angles the model with actual BRDF data performs slightly better
- Bottom left: radiation pattern of the short reflector
  - At large emission angles both models predict the radiation pattern well
  - At small emission angles there is a very good agreement between the model with the actual BRDF data and the measured radiation pattern