

Full 3D BSDF spectroradiometer

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Introduction

To expedite colour and gloss measurements, the CIE has recommended some basic geometries regarding illumination and viewing angles. For colour measurements, the 45:0 geometry, d:8 geometry and multi-angle geometry are recommended in reflection as well as in transmission. Gloss measurement requires angles of incidence of 20°, 60° or 85° dependent on the gloss value. These specific geometries are usually implemented in colour and gloss measuring instruments respectively.

There are, however, many surfaces that cannot be adequately measured using such limited conditions. Gonio-apparent or special-effect colours (e.g. coloured, metallic finishes, applied to many automobiles) which change in colour according to the angle of illumination and viewing, have rapidly grown in popularity over the last 50 years. Nowadays, dramatic colour effects can be achieved. Furthermore, gloss values of very matt and black samples are too low to be measured accurately by industrial gloss meters.

Any gloss and colour measurement can be related to some particular value of the general spectral Bidirectional Scatter Distribution Function (BSDF). The use of a multifunctional spectroradiometer to measure this BSDF is an interesting tool to study all issues related to colour and gloss characterization.

Description

In our laboratory, we have built a goniospectroradiometer which allows us to determine the absolute Bidirectional Scatter Distribution Function (BSDF) of an object (Fig. 1). Spectral properties can be measured at any spherical angle of illumination of the sample and at almost any spherical viewing angle using a detector circulating around the sample with two degrees of freedom. A Xenon light source is used for the illumination of the specimen. Having large emission intensities in the blue-violet region of the spectrum, a good signal to noise ratio can be achieved over the whole visible spectrum. While measuring the dark current, the incident light beam is directed to a silicon photodiode. The response of this detector allows us to compensate for the fluctuations in the light source output. The detector head consists of a lens and a very small integrating cavity which is coupled to a spectrometer/CCD detection system with a quartz fibre. The fibre is immobile during measurements. The spectral bandwidth is 10 nm. The diameter of the lens is 20 mm. The distance from the specimen to the detector head is 750 mm. An aperture stop before the lens enables us to decrease the angular resolution below 1.5°. The use of an automated filter-wheel carrying three neutral density filters and of the CCD integration time results in a dynamic range of 6 decades. This is necessary as we measure the incident power on the sample with the same detector head. Absolute spectral BSDF-values can be calculated from dark current corrected CCD readings (counts) according to ASTM E1392.



Fig. 1 Picture of the BSRDF goniospectroradiometer

Measurements

Absolute test measurements were executed on the CERAM matt tile and a good agreement with NPL measurements was obtained. Regular transmittance of a glass plate indicate 92% as expected. BRDF values as low as 0.015 sr^{-1} on a black textured PU sheet used in automobile dashboards were obtained.

Finally, we did a full characterization of a gonio-apparent ChromaFlair® sample, of a glass plate with a dichroic coating and of a set of black, grey and white NCS gloss samples, with an angle of incidence of 60° are shown.

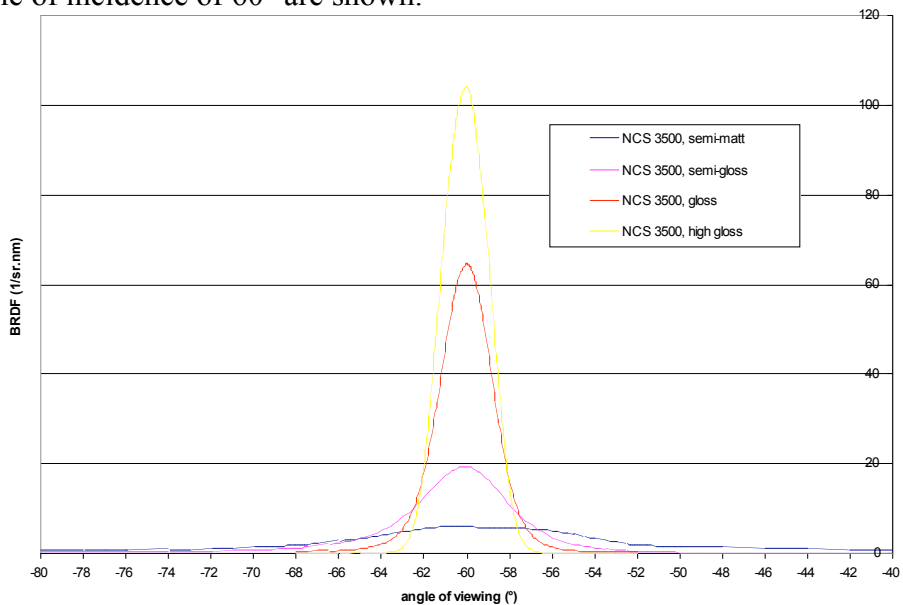


Fig. 2. Gloss measurements on the NCS gloss scale colour 3500