Development of a Sample Holder for Spectral Emissivity Measurements of Semitransparent Materials

Julian Gieseler [C, S], Christian Monte and Albert Adibekyan
Temperature and Synchrotron Radiation, Physikalisch Technische Bundesanstalt, Berlin, Germany
julian.gieseler@ptb.de

Robert Kersting
Additive Manufacturing, Fraunhofer-Institut für Produktionsanlagen und Konstruktionstechnik, Berlin, Germany

Jörg Hollandt
Temperature and Synchrotron Radiation, Physikalisch Technische Bundesanstalt, Berlin, Germany

Active thermography for non-destructive testing is increasingly applied when observing and analysing optically semitransparent components. Furthermore, the knowledge of the spectral emissivity of components, which are used as refractive or transmitting optical elements in the mid infrared wavelength range, is often a requirement when designing and operating critical optical systems. Hence, to obtain quantitative data with small uncertainties in the preceding applications, knowledge of the emissivity is required. For this purpose, the facilities for the measurement of emissivity at PTB were extended to enable emissivity measurements of semitransparent samples. For the measurement, the semitransparent sample is heated in a temperature range from 10 °C to 90 °C between two annular heating plates. From the backside, the sample is irradiated by a black plate radiator operated in the temperature range from -50 °C to 90 °C. Its radiation enters the sample and the resulting spectral radiance, which is a combination of the transmitted radiation of the plate radiator and the emitted radiation from the sample itself is measured by a Fourier transform-infrared spectrometer. A corresponding sample holder was designed, its thermal performance optimized with a finite element analysis and realized. The sample holder's heated components have a complex internal structure to achieve a good thermal uniformity. These parts were manufactured by selective laser melting of copper at Fraunhofer IPK. The thermal uniformity of the surface of the heated components was verified by thermography. To evaluate the data measured with the newly designed sample holder, a mathematical model of conjugated radiative transfer considering emission, isotropic scattering and multiple reflections in optically homogeneous media was derived. Test measurements on samples designed to allow the simultaneous measurement of their internal temperature gradient to verify the applicability of this model will be shown.