Virtual Spherical Reflectometer for Materials in Varying Thermal and Aggregate States

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We describe a novel instrument designed for the indirect measurement of emittance of materials in a variety of aggregate states including solid, powder and liquid forms undergoing processing over a range of temperatures up to and beyond the melting point. The instrument is used to perform hemispherical-directional reflectance factor measurements, from which the emittance can be derived from Helmholtz reciprocity, Kirchhoff's law and energy conservation. The instrument consists of the following elements: 1) a hemisphere coated with a near-Lambertian diffuser, 2) a high reflectance specular baseplate containing a sample port located at its center, 3) a ring of light-sources around the circumference of hemisphere base, consisting of light-fiber-fed transmissive diffusers and providing illumination to the hemisphere and indirect uniform illumination of the sample, and 4) a viewing port near the center of the hemisphere for receiving reflected light from the sample or reference. The combination of a diffuse hemisphere and high reflectance specular base provides an environment equivalent to that of an integrating sphere for these reflectance measurements. The light-fibers are fed with laser sources and measurements of the reflected light are made with filter radiometers or spectrometers. The reflectometer has been designed to operate within the chamber of a testbed for the study of additive manufacturing processes. It will be used in a facility under development named AMMT-TEMPS (Additive Manufacturing Metrology Testbed - Temperature and Emittance of Melts, Powders and Solids). A primary goal of this facility is the characterization of emittance of materials undergoing laser heating of the additive manufacturing process, enabling accurate determination of true surface temperature of the materials and providing data for modeling of the processes. Preliminary test results of the constructed reflectometer will be presented.