Measurement of Characteristic Spatial Distributions of Emissivity and Temperature of Laser Powder Bed Fusion Processes at the NIST AMMT Facility

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Additive manufacturing involving layer-wise selective laser melting of a powder material, or laser powder bed fusion (LPBF), is a fast-growing industry. At the Additive Manufacturing Metrology Testbed (AMMT) at the United States National Institute of Standards and Technology (NIST) an integrating hemispherical reflectometer has recently been developed to facilitate measurements of spectral hemispherical-directional reflectance factor of the laser-melting heat affected zone (HAZ) during the LPBF process. It is a highly dynamic process, involving motion of the process laser spot across the build area, and has significant thermal gradients across the HAZ. High-speed thermography is the only practical way to deal with both temporal and spatial variability of the process. At the same time, it has been demonstrated that the thermal signature of the LPBF process is statistically reproducible, which allows both averaging of the multiple measurements, as well as use of sequential measurements of different types. The thermal imager enables the acquisition of typical reflectance and radiance distribution across the HAZ. Knowledge of reflectance permits determination of the local emissivity, which together with radiance data is used to determine the thermodynamic temperature at the spectral band of measurements. Finally, thermography at different wavelengths of interest allows determination of spectral emissivity at other wavelengths of interest. Such data are valuable for both modeling and process monitoring purposes.