Emittance and Thermodynamic Temperature Measurement of the Laser Powder Bed Fusion Process's Heat Affected Zone

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Additive manufacturing (AM) is a rapidly expanding field that provides designers and manufacturers a method to make geometries that are impractical or even impossible using traditional manufacturing techniques. One of the leading techniques in AM is laser powder bed fusion (LPBF) which can create near-solid density metallic parts for medical, aerospace, as well as many other applications that require complex structures and rapid prototyping. Despite LPBF's success there is a scarcity of fundamental understanding of what occurs within the heat affected zone (HAZ) present in LPBF. Full comprehension of the HAZ is hampered by a shortage of accurate temperature data required by modelers to make precise simulations of the LPBF process. With the study of the LPBF process in mind, NIST has developed the Additive Manufacturing Metrology Testbed (AMMT) Facility, which provides an open platform for users with full control of the LPBF process parameters and a full suite of diagnostics and sensors to monitor the LPBF process. The Temperature and Emittance of Melts, Powders and Solids (TEMPS) system is one of the diagnostics examining the HAZ within the AMMT.TEMPS utilizes in-situ instrumentation including a novel directional-hemispherical reflectometer and calibration sources in order to provide a means for determining the surface temperature of the HAZ under LPBF conditions. In this paper, we will describe AMMT and TEMPS along with description of the custom instrumentation developed to provide in-situ monitoring and imaging of the HAZ. Finally, we shall present a sampling of data from these systems including spatially resolved emittance and temperature measurements from demonstration experiments performed at the AMMT facility as well results from validation experiments being performed within NIST.