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Millimeter Wave Reflection Properties of Metal Powder Used in Additive Manufacturing (AM)

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Additive manufacturing (AM) is the process of rapid "printing" of complex parts used in a wide range of applications, spanning unlimited types of critical and non-critical components. When considering metal AM, one of the more prominent processes involves layer-by-layer melting of fine metal powder, using an electron or a laser beam, into the desired part geometry. The latter is known as the Laser Powder Bed Fusion (LPBF). The quality of the final printed part is directly affected by the properties of the powder used in the process. This includes, size distribution, surface condition (i.e., whether oxidized), new or recycled, to name a few. Consequently, in-line inspection and evaluation of metal powder properties are of great importance and interest in the AM process. The ability to determine metal powder properties prior to use provides significant manufacturing process *quality control* capability. Millimeter wave nondestructive testing (NDT) techniques offer several advantageous features for this purpose. These methods are non-contact and high-resolution, provide high degree of measurement sensitivity to the mentioned parameters of interest, can provide real-time inspection information, while also being relatively inexpensive. Depending on the operating frequency, millimeter wave signals penetrate a metal powder volume to within several millimeters providing comprehensive information about the powder in an LPBF powder bed. In addition, the reflection properties of the powder are the result of complex electromagnetic interactions between the powder particles and the irradiating wave. Preliminary results have shown the ability to distinguish among powder samples with different size distributions, stratification properties, alloy composition and recycled vs. virgin powder. This presentation provides the electromagnetic foundation of a measurement technique involving an open-ended circular waveguide probe, operating in its TE_{01} mode, as a preferred inspection tool. In addition, results of calibrated reflection coefficient of several diverse powder samples will be presented.

Keywords: Millimeter Wave, Materials Characterization, Laser Powder Bed Fusion, Metal Powder, Additive Manufacturing

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