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Multi-Material Laser Powder Bed Fusion (MM LPBF) offers an approach for fabricating high-resolution components with specially tailored material properties, capitalizing on selective powder deposition (SPD) recoating to deposit and sinter controlled material regions. Advancements in multi-material additive manufacturing (MM-AM) have broadened design possibilities, accommodating functional requirements across various scales. In a practical scenario which leverages this new AM-MM capabilities as well as the high resolution of LPBF, a sheet-based gyroid structure composed of 904L stainless steel and bronze (CuSn10) is subjected to three-point stress testing. This study investigates the fracture mechanics of minimal surface material graded (MSMG) structures through various techniques, including digital image correlation (DIC), finite element analysis (FEA), electron backscatter dispersion spectroscopy (EBSD), and intermittent microcomputed tomography (MCT). By observing as-built defects, cracking, porosity, and fusion zone microstructure, this study presents the influence of factors such as thermomechanical disparities and material compatibility to determine the ultimate origin of failure and propagation patterns.