

Abstract

NiCoCrAlY, a dual-phase (β/γ) alloy in the MCrAlY family, is widely used in gas turbines owing to its excellent oxidation and wear resistance. Although commonly deposited via thermal spray processes, Laser Metal Deposition (LMD) offers a superior alternative for producing dense, durable coatings with enhanced microstructure. This study explores Continuous wave (CW) and Pulsed wave (PW) modes in LMD of NiCoCrAlY coatings on Inconel 718 substrates, focusing on parameter–microstructure–property relationships and crack mitigation without altering the as-received composition. Laser parameters, power, and scan speed in CW-LMD, and frequency and duty cycle in PW-LMD, were systematically varied and correlated with real-time thermal signatures of the melt pool, captured by an IR pyrometer, to obtain a β -dominated microstructure. PW-LMD promoted enhanced grain refinement and β -phase stability due to intermittent solidification. A solidification sequence of $\beta\text{-NiAl} \rightarrow (\gamma\text{-Ni} + \text{Ni}_5\text{Y}) \rightarrow \text{NbC}$ was experimentally established in the LMD-ed coating. Cracking mechanism was primarily governed by brittle fracture of the β -phase below its ductile-to-brittle transition temperature (DBTT) and was effectively mitigated through substrate preheating, as laser parameter tuning led to microstructural deterioration. PW-mode coatings exhibited higher hardness and improved wear resistance (at room temperature and 450 °C), as well as superior oxidation behavior (at 900 °C), while CW-mode coatings demonstrated greater flexural strength. Real-time thermal signals supported strong correlations with microstructure, phase formation, and residual stress, emphasizing the role of substrate temperature in crack suppression. Overall, the study confirms that PW-LMD, combined with substrate preheating, enhances the reliability of NiCoCrAlY coatings for high-temperature turbine applications.

Keywords: *$\beta\text{-NiAl}$, Cracking, LMD, NiCoCrAlY, Phase formation, Pulsed wave LMD.*